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# The Bimonthly Bulletin

Vol. XXII

July-August, 1937

No. 187

## Ohio Agricultural Experiment Station

WOOSTER, OHIO, U. S. A.



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### *Free Bulletin*

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Director



**Recreation Facilities at State Parks**

# WHEAT SEEDING

C. A. LAMB

Time for sowing wheat will soon be here again. Too often the question of seed is neglected until it is too late to do anything about it, and in the last rush before planting, whatever material is at hand is used. This often results in sowing improperly cleaned or otherwise undesirable seed. A little thought ahead of time may do much to insure satisfactory returns. Consideration of a few of the more important points seems well worth while at the present time.

## VARIETY

Drill box surveys of wheat made in this State in 1935 and 1936 show that many farmers, probably about two in every five, do not know what variety of wheat they are growing. This is a really serious matter. More than 200 distinct varieties are grown in the United States. Some are spring wheats; some are winter wheats. Some are soft and some, hard. Some are white; some, red. They fall into groups according to their characteristics and the use to which they may be put. Among the winter wheats, which are grown almost exclusively in Ohio, we find three distinct groups or classes. These are hard red winter, suitable for bread; soft red winter, especially good for cake, pastry, and cracker flours; and white winter, generally characterized in this section of the country as extremely soft wheats.

All three of these classes are grown in Ohio, although the State is especially adapted for the production of the finest of soft red winter wheat. Hard red winter wheats grown here do not make as strong a flour as the same varieties grown on the Great Plains, yet it is too strong for cakes and pastries. White wheats tend to run a little stronger than the market has learned to expect.

A very undesirable situation arises when more than one class of wheat is grown in a district. The Federal Inspection Service made a survey in 1934, and traced the origin of cars of mixed wheat (such as hard and soft, red and white) at four large terminal markets. Thirty-one counties in Ohio sent cars of wheat to these markets which graded "mixed". Normally this reduces the price paid, because such wheat is less desirable for any purpose in the trade. Ohio should grow only soft red winter wheats.

The Experiment Station has made extensive tests of all the well-adapted soft red winter wheats, and data collected from all over the State have provided the best possible basis for farmers to use in choosing a variety. Fortunately, the different wheats behave in much the same way in all sections of Ohio. Fulhio and Trumbull are the two most popular varieties. Gladden is also excellent, but is bearded. It is, however, the most winter hardy of the three. Over the past 20 years there has been no wheat available which exceeds these in yield, when the crops for several consecutive seasons are compared. All three of these varieties were developed at the Ohio Experiment Station.

A new variety has been produced at Wooster and is being multiplied as rapidly as possible. Since only about 5 acres will be harvested in 1937, it will be 2 or 3 years before seed will be available in any quantity. Over a period of 10 years, in 79 comparative trials at 13 locations in Ohio, Thorne, as the new variety has been named, has outyielded Trumbull by 3 bushels per acre and Fulhio by 2 bushels per acre. When available, it is well worth a trial.

### QUALITY OF SEED

Having chosen a variety which has proved its ability to give good yields of high-quality grain, the grower should next consider the quality of the seed. Again considering the drill box surveys mentioned above, it appears that roughly one-quarter of the seed lots sown contain rye. Any appreciable amount of this grain in wheat reduces its milling quality and is almost certain to result in reduced price at the elevator. Rye is very easily seen in a field and can readily be rogued out if the infestation is not too severe. Cleaning up part of the field from which to save seed is probably the easiest way to eliminate the trouble. If the mixture is bad, new, clean seed should be obtained, as it is practically impossible to remove rye from wheat with ordinary cleaning machinery.

About half the seed samples contained cockle, and an equal number contained cheat. One-third of the farmers' seed contained both these bad weeds, and only one-fifth was free of both. Thorough fanning will remove nearly all of these weeds from a seed sample and is well worth the trouble, especially when it is remembered that at the same time the small and cracked kernels are also removed. A well-cleaned seed produces a more uniform stand of stronger plants, which are better able to withstand the winter, and give better yields.

### DISEASES

Plant diseases reduce yield and some, such as stinking smut (bunt), also affect the quality of the flour. The more important seed-borne diseases are loose smut, stinking smut, and scab. Certain root rots which often weaken or sometimes even kill some young seedlings also deserve consideration, because such weakened plants are more susceptible to winter injury.

Loose smut is the hardest of these diseases to control by treatment. Immersion in cold water for 4 to 5 hours is followed by dipping for a minute or two in water at 120° F., then submerging in water at 129° F. for 10 minutes. Temperature control must be quite accurate, for if the temperature is not high enough, the fungus which causes the disease is not killed, and if it is too high, the wheat germ is likely to be killed. Trumbull, however, is immune to this disease, and Fulhio, Gladden, and Thorne have a reasonable amount of natural resistance to it.

The other diseases mentioned can be controlled very satisfactorily with a variety of seed treatments. Among the most desirable agents are copper carbonate dust (either the 20 per cent or the 50 per cent grade) at the rate of 2 to 3 ounces per bushel and New Improved Ceresan at ½ ounce per bushel. The latter preparation has the advantages of controlling the root rots more effectively and not interfering with the rate of sowing in the grain drill. Thorough mixing of the dust with the grain is, of course, essential to best results.

Diseases are by no means a negligible factor. The survey carried on by the Grain Inspection Service and referred to before showed that smutty wheat was received from 24 counties in Ohio. Preventable diseases of small grain in Ohio undoubtedly reduce yields in the State several million bushels, besides reducing grade and price, as does the stinking smut just mentioned.

### SEEDBED PREPARATION

In order that a good variety of wheat may express its superior qualities, it is necessary to give it a good place to grow. This is just as true of crops as it is of animals. Good dairy cows cannot give large production unless well fed and stabled; neither can the best of wheat varieties yield 40 bushels per acre unless given a good place to grow. Using one variety, 8 years' experiment at Wooster showed that preparation of seedbed made a difference of nearly 5 bushels per acre. Early preparation was best. When wheat follows a small grain crop, plowing soon after harvest is best. If time is not available for this work, disking early to control weeds and plowing as soon as possible are desirable. When farm work or late removal of the preceding crop makes early working impossible, the job should be done as soon as possible and as thoroughly as time permits. The grower should provide enough plant food for the wheat to make adequate fall growth to enter the winter in the best possible condition. If the variety grown has the inborn capabilities of responding, this work will be amply repaid at harvest time.

### SOWING ON THE FLY-FREE DATE

Each year the Department of Entomology at the Station makes a survey of the prevalence of the Hessian Fly and recommends a date for each section of the State before which it is not desirable to sow wheat. Experiments over many years have definitely proved the wisdom of following this recommendation. If the infestation is checked by unfavorable weather or other cause, earlier planting may give higher yields, but if the infestation is normal, or heavier than normal, early planting gives a definitely lower yield. General early planting for a few successive seasons would result in rapid multiplication of the pest, and a very serious situation would develop. Over a period of, say, 10 years, sowing on the fly-free date has given higher average yields than sowing either earlier or later.

### SUMMARY

Ohio can produce a very superior soft red winter wheat, and farmers should standardize on this class. If they do, the enviable reputation which wheat from most sections of the State now enjoys will be maintained and enhanced. Extensive trials have shown that the Trumbull, Fulbio, and Gladden varieties, all developed at the Ohio Experiment Station, are the most desirable ones to grow. Thorne will outyield these, and should be given a thorough trial as soon as seed is available. Every effort should be made to sow clean seed; treatment for seed-borne diseases is well worth while. In order that these good varieties may express their high yielding ability, adequate preparation of seedbed and a reasonable level of fertility are necessary. Sowing on, or as soon after the fly-free date as possible has been shown to give best results over a period of years.

For more detailed information on seed treatment, fertilizers, and the like, growers should consult Extension Bulletin No. 81, "Wheat Growing in Ohio". This may be obtained from the Agricultural Extension Service, Ohio State University, Columbus, Ohio.

## GENERALIZED LAND-USE SUGGESTIONS FOR OHIO<sup>1</sup>

J. S. CUTLER<sup>2</sup>, A. H. PASCHALL<sup>3</sup>, AND G. W. CONREY<sup>4</sup>

Although information on desirable land use is meager, it is possible to make some tentative general suggestions for land use. The recommendations are based on studies made on the several soil-conservation projects, experiences in CCC camp work areas, and on the cooperative surveys made jointly by the Agricultural Adjustment Administration, the Ohio Agricultural Experiment Station, and the Soil Conservation Service.

For convenience, the State has been divided into the districts indicated in Figure 1, showing the principal land-use problem areas from the soil conservation viewpoint. In dividing the State into these major land-use sections, similarity of soils, topography, and erosion have been the criteria, since the land factors are in general the most important factors to be considered in determining proper land use.

For convenience, slopes have been classified as follows:

SLOPE		INTERPRETATION
A	Cropland	Erosion control not usually necessary
B	Cropland	Erosion control necessary
BB	Cropland	Erosion control absolutely essential
		Requires strip cropping and long rotations
C	Pasture	
D	Forest	

The significance of slope class in terms of per cent of slope is indicated by Table 1 showing the slope class limits employed in the four Ohio soil conservation project areas.

TABLE 1.—Slope Class Limits, Ohio Projects

Slope class	Ohio-1 Zanesville		Ohio-2 Wooster	Ohio-3 Hamilton	Ohio-4 Mt. Vernon
	Lime- stone	Sandstone and shale			
A.....	<i>Pct.</i> 0-5	<i>Pct.</i> 0-5	<i>Pct.</i> 0-3	<i>Pct.</i> 0-3	<i>Pct.</i> 0-3
B.....	5-12	5-12	3-7	3-8	3-7
BB.....	12-25	12-20	7-12	8-12	7-12
C.....	25-40	20-30	12-20	12-20	12-20
D.....	40+	30+	20+	20+	20+

<sup>1</sup>This article is a continuation of the discussion on problems in adjusting land use presented in the May-June Bimonthly.

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<sup>3</sup>In charge of Conservation Surveys, Region 3, Soil Conservation Service, U. S. Department of Agriculture.

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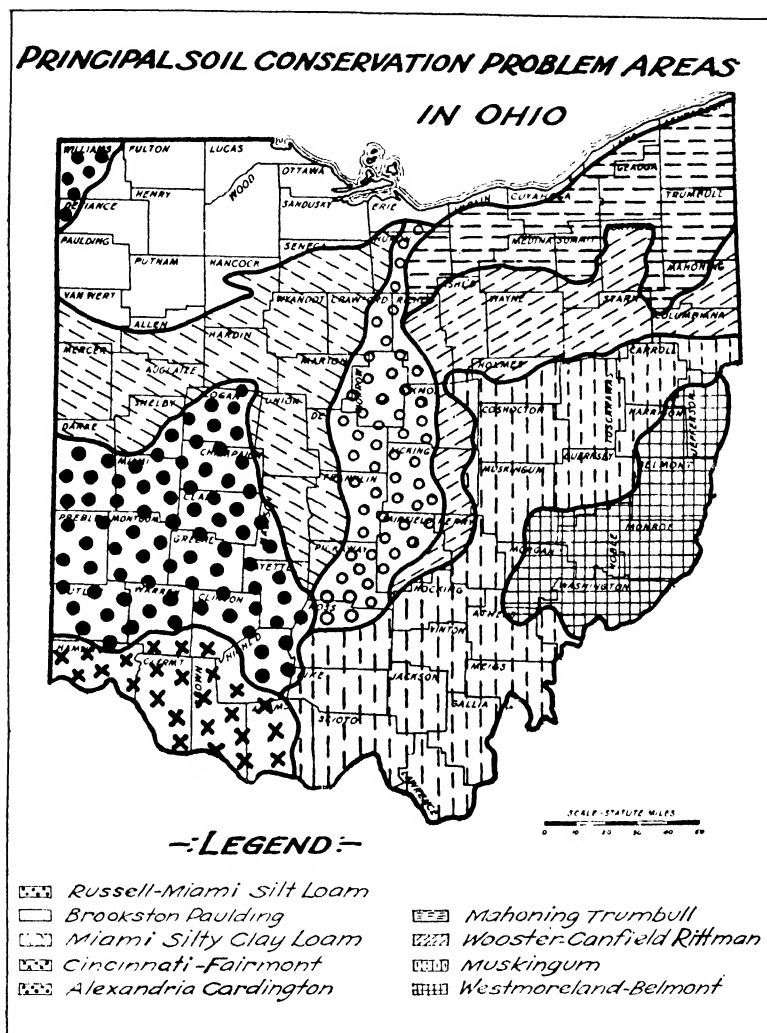


Fig. 1

### SOUTHEASTERN OHIO

A study of the Salt Creek project indicates that certain land-use shifts are not only desirable but also essential to the future agricultural prosperity of this section of the State. Approximately one-third of the cropland is on "B" and "BB" slopes. Corn and other intertilled crops should be shifted from the "BB" and "C" slopes (slopes over 12 per cent) to the smoother lands; pasture on land of less than 12 per cent slope should be used for cultivated crops. About 6 per cent of the "D" slopes (over 30 per cent) are now in pasture and should be retired to forest. This shift would cause an increase of about 5 per cent in the land in forest.

*MUSKINGUM AREA*

1. Cultivated crops may be grown on slopes up to 20 per cent, provided proper soil-conservation measures, such as strip cropping, adequate fertilization and liming, and a rotation containing not less than 2 to 3 years of a good legume-grass meadow, are followed.

2. Soil-conservation measures should be adjusted to the erosion problem as indicated by the steepness of slope and soil type. Contour farming and strip cropping should be practiced on all slopes in excess of 5 per cent. As the slope of the land increases, the width of the strip of cultivated crop should decrease and the rotations should be longer, with more years of meadow intervening between cultivated crops.

3. The bottoms now in pasture, with the exception of the "crawfishy" lands, should be utilized for rotated crops.

4. Slopes up to 30 per cent, not too seriously eroded, may be utilized for pasture with adequate fertilization and liming, and proper management. Rough, broken, or badly gullied areas which cannot be treated with machinery should be retired to forest. Late fall or early spring grazing and overgrazing in midsummer should be avoided. Clipping occasionally is necessary for the control of weeds.

5. The proportion of idle land in this section is too great. Much of it should be reforested.

6. With proper management of forested lands a much greater future return can be obtained.

*WESTMORELAND—BELMONT AREA*

1. Slopes up to 20 per cent are satisfactory for cultivated crops when good soil-conservation methods are used.

2. Soil-conservation methods should be adjusted to the erosion problems. All short slopes above 5 per cent should be contour farmed. All short slopes in excess of 10 per cent and all long slopes (200 to 300 feet) over 5 per cent should be contour strip cropped. Some variation from exact contour is permissible on the more productive soils.

3. Since these soils contain some lime in the parent material, they usually support better pastures than those in the Muskingum area. Slopes up to 40 per cent may be used for pasture with adequate fertilization and good pasture management.

4. Bottom lands should be shifted from pasture to crop wherever possible. Some stream bank protection or drainage may be necessary.

5. All rocky, rough, broken areas now in pasture that cannot be treated with machinery should be reforested.

*WESTERN OHIO**BROOKSTON—PAULDING AREA*

The level topography does not require shifts in land use. Soil conservation is, however, an important problem. The following recommendations are made:

1. Adoption of a crop rotation providing for the systematic use of legumes, both as meadow and green manure crops on the dark-colored soils, and legume-grass mixtures on the light-colored soils. Organic matter depletion of these soils through grain farming has markedly increased the difficulties of tillage.
2. Extension and protection of existing tile drainage systems.
3. More livestock are desirable from the soil-conservation viewpoint.
4. The heavy soils should not be worked when too wet.

### *MIAMI SILTY CLAY LOAM AREA*

Surveys in this area indicate that few shifts in land use are essential, except that occasional breaks bordering the streams should be retired to pasture and forest.

1. There should be a marked increase in the deep-rooted leguminous crops for their effect on the physical condition of the soil and on drainage. Longer crop rotations are needed (4-year).
2. Surface drainage should be developed where needed.
3. A permanent grass cover should be established on all slopes above 7 per cent which are not used for forest.

### *RUSSELL-MIAMI SILT LOAM*

Studies at the Hamilton project and in the adjacent camp areas indicate that one-tenth of the cropland is now on slopes too steep and should be shifted to the smoother areas now included in pasture. About one-sixth of the pasture land that is on "D" slopes should be retired to forest.

1. Rotated cropland should be limited to slopes of less than 7 per cent.
2. On the longer slopes (200 to 300 feet) on these medium-textured soils, either strip cropping or terracing or both are essential to reduce runoff.
3. Steep slopes of less than 20 per cent adjacent to streams should be retired to permanent meadow or pasture. All slopes above 20 per cent should be reforested.
4. In general, a 4-year crop rotation with 2 years of hay or rotation pasture would be more satisfactory than the common 3-year rotation.

### *CINCINNATI-FAIRMOUNT AREA*

1. Corn and small grain should not be grown on slopes in excess of 12 per cent on limestone soils and 7 per cent on glaciated soils. Attention must be given to erosion-control methods on all slopes in excess of 3 per cent.
2. Tobacco may be grown on limestone slopes up to 25 per cent, provided the land is reseeded after each tobacco crop. The practice of following tobacco with corn should be discontinued because of the excessive erosion occurring the second year after breaking. Tobacco fields should be laid out in narrow belts parallel to the contour.
3. Slopes up to 35 per cent on limestone soils may be pastured satisfactorily if properly fertilized and not overgrazed.
4. Badly gullied slopes and slopes above 35 per cent should be reforested.

## NORTHEASTERN OHIO

*WOOSTER-CANFIELD-RITTMAN AREA*

Studies of the Wooster and Mt. Vernon projects, together with studies in Ashtabula County and observations in the camp areas, indicate that there are sufficient "A" and "B" slopes for the production of all of the intertilled crops. Crops now grown on "BB" slopes should be shifted to "A" and "B" slopes now in pasture.

A small amount of cropland is found on "C" and "D" slopes. These lands should be retired to pasture or forest. In other words, until satisfactory erosion-control measures are adopted, one-fifth of the cropland in northeastern Ohio is on slopes too steep to maintain productivity satisfactorily.

1. Rotation cropland should be limited to slopes of less than 12 per cent.
2. Soil-conservation measures are needed, particularly to control erosion on all slopes in excess of 3 per cent.
3. A 3- to 4-year crop rotation with a good leguminous sod plowed under should be used. This requires adequate liming.
4. Pastures should be limited to slopes of less than 20 per cent.
5. All slopes in excess of 20 per cent, and badly eroded, broken areas should be retired to forest.

*ALEXANDRIA-CARDINGTON AREA*

Studies in the Mt. Vernon project show that there are sufficient "A" and "B" slopes to take care of the rotated lands, but 11 per cent of the "BB" slopes is now in cultivated crops, indicating that a shift from cropland to pasture, and vice versa, is desirable. Approximately one-third of the cultivated acreage is now on marginal slopes, or those on which it is difficult to maintain productivity because of erosion. Of the 5 per cent idle land, approximately one-half is now on slopes too steep for cultivation and should be retired to pasture and forest.

1. Rotation cropland should be limited to slopes of less than 7 per cent.
2. Soil-conservation measures are needed on all slopes in excess of 3 per cent.
3. Long slopes (200 to 300 feet) should be broken up by strip cropping; the volume of runoff water should be reduced.
4. A 3- to 4-year rotation including a good legume-grass meadow should be used.
5. Pasture should be limited to slopes of less than 20 per cent.
6. Gravelly soils now in pasture should be retired to forest because of their drouthy condition.
7. All slopes above 20 per cent should be in forest.

*MAHONING-TRUMBULL AREA*

Studies in Ashtabula County indicate that no radical shifts in cropland are needed. At present, one-eighth of the idle land is found on slopes of more than 6 per cent. The steep slopes along streams should be retired to forest.

1. Growth and incorporation of leguminous sods and green manures essential for effect on physical condition of soil should be encouraged.
2. Better pasture utilization requires fertilization, liming, and clipping, together with managed grazing.
3. Erosion-control measures should be followed on slopes above 4 per cent.
4. The "C" and "D" slopes along streams should be reforested.

## FEED SALES IN OHIO

J. I. FALCONER

Since 1929 the Department of Rural Economics has received annually from feed manufacturers a report of their feed sales in Ohio. A compilation of the results of this study is given in Table 1.

TABLE 1.—Estimated Tons of Commercial Feeds Reaching the Retail Trade in Ohio, 1929-1936

Feed	Estimated tons					
	1929	1932	1933	1934	1935	1936
<b>Mixed feeds:</b>						
Dairy feeds.....	128,320	25,214	30,181	37,346	40,345	60,817
Poultry feeds.....	189,139	56,805	68,754	78,326	98,489	144,213
Hog feeds.....	36,758	2,898	6,092	7,062	13,901	28,740
Other mixed feeds.....	24,728	13,332	17,028	18,747	16,782	22,838
Total mixed feeds.....	378,945	98,249	122,055	141,481	169,517	256,608
<b>Unmixed feeds:</b>						
Soybean meal*.....			5,206	8,115	20,986	24,287
Cottonseed meal.....	16,708	6,666	8,425	6,981	9,648	11,960
Linseed oil meal.....	24,060	17,099	19,850	13,611	16,033	10,480
Bran.....	59,167	55,066	57,159	48,635	43,419	41,299
Middlings.....	56,431	42,024	55,015	43,830	45,831	45,736
Alfalfa meal.....	4,762	5,507	2,802	2,283	3,142	3,577
Gluten feeds.....	20,257	15,650	21,222	24,259	13,267	13,725
Hominy.....	49,775	11,303	29,517	21,452	22,915	20,342
Tankage.....	8,971	10,434	10,581	11,143	10,444	12,206
Meat scraps.....	12,154	17,389	20,412	20,206	23,639	24,780
Fish meal†.....						673
Milk products.....	1,736	1,739	3,069	2,810	2,950	3,577
All other feeds.....	35,367	8,695	14,278	26,633	28,946	33,903
Total unmixed feeds.....	289,388	191,572	247,536	229,958	241,220	246,545
<b>Total (all feeds).....</b>	<b>668,333</b>	<b>289,821</b>	<b>369,591</b>	<b>371,439</b>	<b>410,737</b>	<b>503,153</b>

\*No report previous to 1933.

†No report previous to 1936.

It will be noted that the sales for 1936 were 25 per cent above those of 1935, 74 per cent above those of 1932, and 25 per cent below those of 1929. A comparison of 1936 with 1935 shows an increase of 51 per cent in mixed feed and an increase of 2 per cent in unmixed feed.

**TABLE 2.—Estimated Total Tons of Commercial Feeds Reaching the Retail Trade in Ohio, 1929-1936**

Year	Total tonnage	Year	Total tonnage
1929.....	668,333	1933.....	369,591
1930.....	566,079	1934.....	371,439
1931.....	410,104	1935.....	410,737
1932.....	289,821	1936.....	503,153

### NEW MONOGRAPH BULLETINS NOT PREVIOUSLY ANNOUNCED

**Bulletin 576. The Influence of the Stage of Maturity on the Chemical Composition and the Vitamin B (B<sub>1</sub>) and G Content of Hays and Pasture Grasses**, by C. H. Hunt, P. R. Record, and R. M. Bethke. This report covers a study of the chemical composition and the vitamin B<sub>1</sub> and G contents of alfalfa, clover, and timothy hays and bluegrass and wheat pasture grass as they are influenced by the stage of maturity of the plant when cut and natural climatic factors. It also includes results of growth experiments with chicks for the purpose of studying their vitamin G requirement, as measured by the rat unit method.

**Bulletin 577. Ohio Agricultural Statistics 1935**, by G. S. Ray, L. H. Wiland, and P. P. Wallrabenstein. This study includes preliminary county estimates of the acreage, yield per acre, and total production of corn, winter wheat, oats, tame hay, and potatoes for 1935 and revised county estimates for 1930-1934 for corn, wheat, and oats and for 1929-1934 for potatoes and tame hay. It also contains preliminary county estimates of the number of livestock on farms January 1, 1936, and revised county estimates for January 1, 1930-1935; prices of farm products; farm wages; and an estimate of the income from the sale of Ohio farm products.

**Bulletin 578. Soil Management Systems in a Young Bartlett Pear Orchard**, by Freeman S. Howlett. The experiments reported in this publication were designed to determine the effects of several systems of soil management upon the growth and fruiting of young Bartlett pears. Four management systems were used: cultivation with cover crop; Kentucky bluegrass sod with added nitrogen; grass or straw mulch; and alfalfa sod.

**Bulletin 579. Fifty-fifth Annual Report.** Administrative reports and accounts of new projects, publications, and the library comprise the director's section. The annual report contains summaries of crop-rotation experiments, better methods of summer seeding, hill fertilization of corn, Ohio soil survey work, pasture experiments, hybrid corn investigations, soil moisture relationships, the effect of fertilizers upon the ash content of wheat, and lawn seedbed work, together with accounts of a new wheat for Ohio and growing corn in tank cultures. It summarizes spray experiments, methods for the control of diseases and insects attacking plants, disease and insect investigations, evaporation surveys, and progress in the breeding of new disease-resistant tomato varieties. Apple breeding, winter injury, peach root studies, raspberry investigations, the effect of growth-promoting substances and different environments on flowers, and vegetable gardening, including irrigation, fertilization, and vegetable variety tests, are discussed briefly. Included also are silage, pasture, and roughage experiments, results on the evaluation of various types of milk, a variety of tests with beef cattle, swine, sheep, and poultry, as well as animal nutrition and disease investigations. Basal metabolism tests, dye investigations, and experiments on the culinary quality of Ohio potatoes are included in the Home Economics section; studies on land use, the income from agricultural products, effects of land purchase on public finance, grade labeling of canned foods, cooperatives, and rural population, relief, and organization, under Rural Economics. Farm operating efficiency, hybrid corn seed and planter relations, crop storage studies, fruit washing, mechanical and biological processing of feeds for cattle, the combine harvester-thresher, surface drainage, State forest projects, reforestation, winter injury in the Station arboretum, forest fire control, white pine blister rust control, and a climatological summary for 1935 are also discussed in this report.

# INDEX NUMBERS OF PRODUCTION, PRICES, AND INCOME

J. I. FALCONER

In March of 1937 industrial production had reached a level of 118 as compared with 121 in March, 1929. Factory payrolls had reached a level of 96 as compared with 41 in 1933 and 109 in 1929.

In April, 1937, the prices of Ohio farm products had reached a level of 134, the highest since April, 1930. During the past year the wages of farm labor have advanced about 20 per cent.

Trend of Ohio Prices and Wages, 1910-1914=100

	Wholesale prices, all commodities U. S.	Weekly earnings N. Y. State factory workers	Prices paid by farmers	Farm products prices U. S.	Ohio farm wages	Ohio farm real estate	Ohio farm products prices	Ohio cash income from sales
1913.....	102	.....	101	101	104	100	105	101
1914.....	99	100	100	101	102	102	105	108
1915.....	102	101	105	98	103	107	106	111
1916.....	125	114	124	118	113	113	121	121
1917.....	172	129	149	175	140	119	182	199
1918.....	192	160	176	202	175	131	203	240
1919.....	202	185	202	213	204	135	218	266
1920.....	225	222	201	211	236	159	212	226
1921.....	142	203	152	125	164	134	132	130
1922.....	141	197	149	132	145	124	127	130
1923.....	147	214	152	142	166	122	134	144
1924.....	143	218	152	143	165	118	133	146
1925.....	151	223	157	156	165	110	159	174
1926.....	146	229	155	145	170	105	155	177
1927.....	139	231	153	139	173	99	147	165
1928.....	141	232	155	149	169	96	154	156
1929.....	139	236	153	146	169	94	151	165
1930.....	126	226	145	126	154	90	128	133
1931.....	107	207	124	87	120	82	89	95
1932.....	95	178	107	65	92	70	63	70
1933.....	96	171	109	70	74	59	69	77
1934.....	110	182	123	90	77	63	85	89
1935.....	117	191	125	108	87	68	110	115
1936.....	118	199	124	114	100	74	118	135
1936								
January...	118	195	122	109	87	.....	107	121
February...	118	195	122	109	.....	.....	111	108
March.....	116	198	121	104	.....	74	108	120
April.....	116	195	121	105	100	.....	112	133
May.....	115	195	121	103	.....	.....	110	136
June.....	115	196	120	107	.....	.....	112	139
July.....	118	198	123	115	105	.....	121	189
August.....	119	202	126	124	.....	.....	131	185
September..	119	198	127	124	.....	.....	127	172
October.....	119	202	127	121	108	.....	124	167
November..	120	201	127	120	.....	.....	123	161
December..	123	211	128	126	.....	.....	127	163
1937								
January...	125	209	130	131	104	77	128	135
February...	126	211	132	127	.....	.....	127	136
March.....	128	218	132	128	.....	.....	129	151
April.....	128	.....	134	130	118	.....	134	167





# The Bimonthly Bulletin

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September-October, 1937

No. 188

## Ohio Agricultural Experiment Station

WOOSTER, OHIO, U. S. A.



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# IRON AND COPPER IN A NORMAL CALF RATION

C. E. KNOOP, W. E. KRAUSS, T. S. SUTTON, AND R. G. WASHBURN

## INTRODUCTION

Previous work done at this Station (1) showed that calves fed whole milk exclusively develop nutritional anemia and that the addition of iron chloride and copper sulfate prevented anemia. In view of this it was thought desirable to study the effect of adding iron and copper to a normal calf ration of milk, hay, and grain.

## PLAN OF THE EXPERIMENT

Nineteen Holstein male calves, comprising three groups, were used in this study. As the calves became available from the Station herd they were assigned to one of the three groups.

The general plan for all calves was to take the calf from the dam at 4 days of age and place it in an individual box stall. Each calf was given whole milk at the rate of 10 per cent of its body weight until a maximum amount of 14 pounds of milk was fed daily, at which level the milk feeding was continued until the calf was 6 months of age. When the calf was 3 weeks of age alfalfa hay (U. S. No. 2) from a second cutting and a grain mixture containing yellow corn, wheat bran, linseed oil meal, and salt were fed according to appetite until each calf was receiving 4 pounds each of hay and grain daily at 5 months of age. The feeding was continued at this level until the calf was 6 months of age. From 6 to 8½ months of age the ration consisted of mixed hay which was approximately half clover and half timothy of medium to good quality and a grain mixture containing yellow corn, oats, wheat bran, linseed oil meal, and salt. Feed requirements at this time were determined according to the Savage standard. The feed changes were made at every 100 pounds of gain in live weight.

Group 1, consisting of nine calves (M385, M386, M387, M389, M418, M422, M427, M432, and M436), served as the control group. The first four calves were fed in 1933; the others, from 1934 to 1936. The iron content of the ration, as calculated on the basis of the dry feeds consumed, was 0.0176 per cent and the copper content was 0.0013 per cent. (See Table 1).

Group 2, consisting of five calves (M419, M426, M433, M435, and M437), received in addition to the basal ration, iron as iron chloride and copper as copper sulfate, according to live weight gains. These minerals were fed in such quantities as to make the total daily intake from the beginning to 150 pounds, 400 milligrams of iron and 40 milligrams of copper; i. e., if a calf were receiving 100 milligrams of iron and 10 milligrams of copper in the hay and grain, it would then receive 300 milligrams of iron in iron chloride and 30 milligrams of copper in copper sulfate. For each additional gain of 50 pounds in weight, the iron intake was increased 100 milligrams and the copper, 10 milligrams. This system of iron and copper supplementary feeding was similar

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<sup>1</sup>Knoop, C. E., W. E. Krauss, and R. G. Washburn. 1935. The development of nutritional anemia in dairy calves. *Jour. Dairy Science* 18: 337-347.

to that previously reported. The total iron content of the ration, including iron chloride, calculated on the basis of the dry feeds consumed, was 0.0279 per cent and the copper content, including copper sulfate, was 0.0035 per cent.

Group 3, consisting of four calves (M442, M443, M448, and M449), also received in addition to the basal ration, iron as iron chloride and copper as copper sulfate, on the basis of live weight gains. These minerals were fed in such quantities as to make the total daily intake from the beginning to 150 pounds, 200 milligrams of iron and 20 milligrams of copper. For each additional gain of 50 pounds in live weight, the iron was increased 200 milligrams and the copper, 8 milligrams. The total iron content of the ration, including iron chloride, calculated on the basis of the dry feeds consumed, was 0.0369 per cent and the total copper, including copper sulfate, was 0.0022 per cent.

TABLE 1.—Number of Calves, and Average Feed Consumption

	Group 1	Group 2	Group 3
Calves, no. ....	5†	5	4
Whole milk, lb. ....	2288	2314	2389
Grain, lb. ....	666	666	651
Alfalfa hay, second cutting (U. S. No. 2), lb. ....	309	312	310
Mixed hay (timothy and clover), lb. ....	663	669	658
Inorganic iron, as iron chloride, gm. ....	.....	76.70	140.90
Total iron consumed*, gm. ....	131.07	209.29	271.50
Percentage of iron in the rations ....	0.0176	0.0279	0.0369
Inorganic copper, as copper sulfate, gm. ....	.....	16.15	5.99
Total copper consumed*, gm. ....	10.20	26.37	16.30
Percentage of copper in the rations ....	0.0013	0.0035	0.0022
Ratio of total iron to total copper consumed ....	13:1	8:1	17:1

*Whole milk .....	0.00004	per cent iron	0.000015	per cent copper
Grain .....	0.00615	per cent iron	0.00100	per cent copper
Alfalfa hay,				
second cutting (U. S. No. 2)....	0.0433	per cent iron	0.0022	per cent copper
Mixed hay (timothy and clover)....	0.0171	per cent iron	0.00136	per cent copper

†The feed data for the four calves fed in 1933 are not included in this table.

The roughages fed in this experiment were put aside for this study, composite-sampled, and analyzed for iron and copper. All grain mixtures were freshly prepared from time to time. An occasional grain mixture was analyzed for iron and copper. Water and salt were before the calves at all times. Wood shavings were used as bedding.

Live weights and measurements of the height at withers were taken at birth and every 2 weeks thereafter. The number of erythrocytes and the hemoglobin concentration of the blood were determined when the calves were approximately 2 days of age and every 2 weeks thereafter. Calcium and phosphorus of the blood serum were determined when the calves were 12 to 19 days of age, and after that, at approximately monthly intervals. All calves were killed at 255 days of age, and post-mortem examinations were made. The fresh livers and testes were analyzed for iron and copper; portions of the testes were examined histologically. Physical measurements of the metacarpal and metatarsal bones were made. Ash, calcium, and phosphorus of the metacarpal, metatarsal, and fifth rib bones were determined. Many of the above observations and chemical analyses were not made on calves M385, M386, M387, and M389 (first four calves in the control group). All determinations were made in accordance with accepted methods.

## RESULTS

## GENERAL HEALTH

Six of the nine calves in Group 1 (iron, 0.01 per cent; copper, 0.001 per cent) showed signs of a disturbance in digestion, indicated by a total of 15 cases of soft to watery condition of the feces and eight cases of feed refusals. This condition in the control calves is characteristic of the calves in the Station herd.

A disturbance in digestion was noticed in all the calves of Group 2 (iron, 0.02 per cent; copper, 0.003 per cent) as indicated by watery feces seven different times and feed refusals four times.

There was less evidence of a disturbance in digestion in the calves of Group 3 (iron, 0.03 per cent; copper, 0.002 per cent), as compared with Groups 1 and 2. There was, however, a tendency for their feces to be very soft in texture.

## GROWTH

The gains in live weight and height at withers for the three groups of calves are given in Table 2. When the calves were 6 months of age the system of feeding was changed from milk, alfalfa, and grain to mixed hay and grain. At this time the average weights of Groups 1, 2, and 3 were 473, 483, and 503 pounds, respectively. From this time to the end of the experiment (8½ months) the calves in Group 2 (iron, 0.02 per cent; copper, 0.003 per cent) made constant and rapid gains. Their average weight when the experiment finished was 33 pounds more than that of the calves in Group 1 (control) and 24 pounds more than that of the calves in Group 3 (iron, 0.03 per cent; copper, 0.002 per cent). In other words, the average 2-week gains in live weight throughout the experiment for Groups 1, 2, and 3 were 29.0, 31.0, and 29.6 pounds, respectively. The differences between these averages are not significant.

TABLE 2.—Rate of Growth of Calves Fed Normally and of Those Fed a Normal Ration with Iron and Copper Added

Age	Group 1 Nine calves (iron, 0.017%; copper, 0.001%)		Group 2 Five calves (iron, 0.027%; copper, 0.003%)		Group 3 Four calves (iron, 0.036%; copper, 0.002%)	
	Weight	Height	Weight	Height	Weight	Height
	<i>Lb.</i>	<i>Cm.</i>	<i>Lb.</i>	<i>Cm.</i>	<i>Lb.</i>	<i>Cm.</i>
2 days.....	104	77.9	104	76.6	107	77.5
4 weeks.....	127	80.3	125	78.3	137	80.5
8 weeks.....	171	83.3	167	83.4	184	85.6
12 weeks.....	229	89.9	217	88.9	239	92.7
16 weeks.....	292	96.3	285	94.4	301	98.3
20 weeks.....	362	101.4	359	99.0	375	103.1
24 weeks.....	432	105.7	442	105.1	456	108.7
26 weeks*.....	473	108.8	483	108.0	503	110.2
28 weeks.....	514	110.7	525	109.0	544	112.2
32 weeks.....	564	114.3	584	111.2	587	114.3
36½ weeks.....	630	117.2	663	116.0	639	117.6

\* Ration changed from milk, alfalfa hay, and grain to a ration of mixed hay (timothy and clover) and grain.

The average growth in height at withers, in 2-week periods, for Groups 1, 2, and 3 was 2.31 centimeters, 2.32 centimeters, and 2.36 centimeters, respectively.

**ERYTHROCYTE AND HEMOGLOBIN CONTENT  
OF THE BLOOD**

The average number of erythrocytes (red blood corpuscles) at 2 days of age for the calves in Groups 1, 2, and 3 was 8.08, 8.58, and 8.26 millions, respectively, per cubic millimeter of blood. Similarly, the average amount of hemoglobin per 100 cubic centimeters of blood was 8.9, 10.1, and 9.0 grams, respectively, for the groups.

A study of Table 3 will show that there is a general tendency for the number of erythrocytes and the hemoglobin values to increase from 2 days of age to 2 to 6 weeks of age, and then gradually decrease to the end of the experiment for all the groups. However, feeding a higher level of copper, as was done in Group 2, (iron, 0.02 per cent; copper, 0.003 per cent) increased the number of erythrocytes for the first 22 weeks of age as compared with Group 1 (control) and Group 3 (iron, 0.03 per cent; copper, 0.002 per cent). After 22 weeks of age the number of red blood corpuscles was practically the same for all groups, with a gradual reduction to the end of the experiment.

**TABLE 3.—Number of Red Blood Corpuscles and Amounts of Hemoglobin  
in the Blood of Calves Fed Normally and Those Fed a  
Normal Ration with Iron and Copper Added**

Age	Group 1 Nine calves (iron, 0.017%; copper, 0.001%)		Group 2 Five calves (iron, 0.027%; copper, 0.003%)		Group 3 Four calves (iron, 0.036%; copper, 0.002%)	
	Red blood corpuscles	Hemoglo- bin	Red blood corpuscles	Hemoglo- bin	Red blood corpuscles	Hemoglo- bin
	<i>Million</i>	<i>Gm.</i>	<i>Million</i>	<i>Gm.</i>	<i>Million</i>	<i>Gm.</i>
2 days .....	8.09	8.9	8.58	10.1	8.26	9.0
2 weeks .....	9.63	10.7	10.36	11.0	10.01	9.1
4 weeks .....	9.32	9.2	12.16	11.7	10.02	11.1
6 weeks .....	10.75	10.0	11.35	11.5	10.86	11.4
8 weeks .....	10.58	9.1	10.99	10.6	10.23	9.7
10 weeks .....	10.20	9.4	11.85	11.3	10.38	9.8
12 weeks .....	9.27	8.7	11.72	11.5	9.57	9.0
14 weeks .....	9.87	9.2	10.95	10.1	10.19	10.7
16 weeks .....	9.73	9.4	10.62	10.0	9.40	10.5
18 weeks .....	9.56	9.8	10.34	10.3	8.83	10.5
20 weeks .....	9.62	9.6	10.09	9.8	9.47	10.1
22 weeks .....	8.96	8.4	9.31	9.1	8.79	9.9
24 weeks .....	8.79	9.3	8.83	8.3	7.93	9.1
26 weeks .....	8.71	9.4	8.77	9.3	8.25	9.4
28 weeks .....	8.83	9.3	8.63	8.6	8.46	9.4
30 weeks .....	8.32	8.7	8.34	8.7	7.84	8.9
32 weeks .....	7.77	8.0	7.70	8.4	9.21	9.8
34 weeks .....	7.69	8.7	7.51	7.3	7.75	8.3
36½ weeks .....	8.06	8.4	8.11	9.1	7.59	9.6

The hemoglobin content of the blood in Group 1 fluctuated considerably during the first 8 weeks; after that it remained quite constant until 28 weeks of age. From 28 weeks to 36½ weeks the average amount of hemoglobin decreased approximately 1 gram per 100 cubic centimeters of blood. The hemoglobin content for Group 2 and Group 3 remained at a high level until the calves were 18 to 20 weeks of age, after which it decreased at approximately the same rate as that of the calves in the control group. Hemoglobin fluctuations followed very closely the fluctuations in the numbers of red blood corpuscles.

In general, feeding less iron and more copper (Group 2, iron, 0.02 per cent; copper, 0.003 per cent) as compared with feeding more iron and less copper (Group 3, iron, 0.03 per cent; copper, 0.002 per cent) tends to increase the number of erythrocytes and more uniformly increases the hemoglobin content of the blood during the first 12 to 20 weeks of life.

#### CALCIUM AND PHOSPHORUS IN THE BLOOD SERUM

The inorganic calcium and phosphorus contents of the blood serums are given in Table 4. Even though there was less calcium in the blood serum of Group 3, it was not significantly less as compared with the other groups. Serum phosphorus was practically the same in all groups throughout the experiment.

TABLE 4.—Average Calcium and Phosphorus of the Blood Serum of the Calves Bled at Monthly Intervals

	Group 1 (iron, 0.017%; copper, 0.001%)	Group 2 (iron, 0.027%; copper, 0.003%)	Group 3 (iron, 0.036%; copper, 0.002%)
Calcium (mg. per 100 cc.) . . . . .	11.48	11.15	10.88
Phosphorus (mg. per 100 cc.) . . . . .	8.58	8.28	8.48

#### GROWTH OF CERTAIN ORGANS

The sizes of the testes (1), spleens, livers, and hearts were not significantly changed by the feeding of additional iron and copper (Table 5). The hearts from the calves in Group 3 tended to be slightly larger than the hearts taken from the calves in Groups 1 and 2, however.

TABLE 5.—Average Fresh Weights of Organs of the Calves Fed Normally and Those Fed a Normal Ration with Iron and Copper Added

Group	Weight of testes	Weight of spleens	Weight of livers	Weight of hearts
	<i>Gm.</i>	<i>Gm.</i>	<i>Gm.</i>	<i>Gm.</i>
1. . . . .	285	504	3175	1003
2. . . . .	251	514	3342	1081
3. . . . .	254	519	3377	1345

The quantities of iron and copper stored in the livers were considerably increased by the amounts of iron and copper fed. The iron and copper contents of the testes were not significantly changed by the feeding of these minerals (see Table 6).

The average diameters of the seminiferous tubules of the testes for the calves in Groups 1, 2, and 3 were 202 microns, 207 microns, and 201 microns, respectively. The feeding of additional iron and copper did not produce any appreciable changes in the process of spermatogenesis.

TABLE 6.—Average Iron and Copper Contents of the Livers and Testes\*

Group	Fresh weight Gm.	Dry matter Pct.	Iron			Copper		
			Total Gm.	In fresh tissue Pct.	In dry tissue Pct.	Total Gm.	In fresh tissue Pct.	In dry tissue Pct.
Livers								
1.....	3278	29.1	0.1555	0.00379	0.01306	0.1395	0.00340	0.01171
2.....	3342	29.4	0.2069	0.00619	0.02106	0.3486	0.01044	0.03551
3.....	3377	28.5	0.2779	0.00823	0.02883	0.2384	0.00706	0.02474
Testes								
1.....	294	14.0	0.00398	0.00135	0.00964	0.00261	0.00088	0.00632
2.....	251	15.4	0.00368	0.00146	0.00952	0.00186	0.000740	0.00481
3.....	254	13.4	0.00521	0.00205	0.01524	0.000745	0.00029	0.00219

\*Data from the first four calves in Group 1 are not included.

### BONE STUDIES

A study of Table 7 will show that the physical measurements of the metacarpal and metatarsal bones were practically the same in Groups 1 and 2; whereas the metacarpal and metatarsal bones in Group 3 were slightly smaller and weaker. Similar differences did not appear in the chemical analyses of these bones, however, (see Table 8).

TABLE 7.—Average Physical Measurements of the Metacarpal and Metatarsal Bones

Group	Fresh weight	Length	Smallest diameter	Width of epiphysis	Volume	Density	Breaking strength
	<i>Gm.</i>	<i>Cm.</i>	<i>Cm.</i>	<i>Cm.</i>	<i>Cc.</i>	<i>Gm. per cc.</i>	<i>Lb.</i>
1.....	347	23.17	2.58	6.59	263	1.31	1946
2.....	346	23.03	2.62	6.68	264	1.29	2110
3.....	333	23.30	2.48	6.43	253	1.30	1689

There were slightly less bone ash, calcium, and phosphorus in the rib bones of the calves in Group 3 than in the rib bones of the calves in Groups 1 and 2. Statistically, these differences are not significant.

TABLE 8.—Average Chemical Analyses of the Metacarpal, Metatarsal, and Rib Bones

Group	Metacarpal and metatarsal bones			Fifth rib bones		
	Ash	Calcium	Phosphorus	Ash	Calcium	Phosphorus
	<i>Pct.</i>	<i>Pct.</i>	<i>Pct.</i>	<i>Pct.</i>	<i>Pct.</i>	<i>Pct.</i>
1.....	63.40	24.20	12.18	60.56	22.96	11.51
2.....	63.62	24.26	12.09	60.04	22.92	11.47
3.....	63.85	24.47	12.08	58.77	22.27	10.85

### DISCUSSION

During the progress of this experiment some calves were born in the Station herd with enlarged necks, indicating a partial iodine deficiency. Three calves (one calf in Group 2 and two in Group 3) with enlarged necks were used in this experiment. To incorporate iodine into the basal ration after the experiment was in progress might have altered the results in one way or another. Therefore, no iodine supplementary feeding was started. To verify this belief, that a partial iodine deficiency existed in this experiment, the thyroid glands were removed from all the calves and weighed when post-mortem examinations were made. The thyroid glands from the calves of Group 1 averaged 35 grams; those of Group 2, 35 grams; and those of Group 3, 42 grams. Several of them weighed over 50 grams each. The average size of these glands is indicative of a partial iodine deficiency. Even though this general condition was not serious, it may have been a factor of some importance.

### SUMMARY

In general, this study indicates that the feeding of copper to calves receiving a ration of milk, alfalfa or mixed hay, and grain may have some beneficial effects and that the feeding of iron to such calves probably has no beneficial effect.

According to this work a calf ration, on a dry basis, which contains 0.0176 per cent of iron and 0.0013 per cent of copper furnishes adequate amounts of these minerals for normal growth up to 8½ months of age.

# EFFECTS OF VARIATION IN THE SOIL WATER CONTENT ON THE GROWTH OF CERTAIN SPECIES OF PLANTS<sup>1</sup>

WALTER WENTWORTH WIGGIN<sup>2</sup>

## INTRODUCTION

Few critical data are available on the effect of growing plants in soils in which the soil water content has been accurately controlled. In this investigation a study was made of the suitability of auto-irrigator clay pots as an experimental method of controlling soil water contents and of the effect of variations in soil water content on the growth and development of certain species of plants.

In 1928 Wilson<sup>3</sup> described an improved type of auto-irrigator pot, in which the inner wall of a double-walled pot is the surface from which water is supplied to the soil. Auto-irrigators of this design have a greater water-supplying surface than the types of auto-irrigators which had previously been used. One additional advantage of these pots is that the roots of the plant grow in the position they normally take in a flower pot, rather than being located around a porcelain cone or cylinder which served as the water-supplying surface in the older types of irrigators.

## METHODS

The moisture contents of the soil in the auto-irrigator pots were determined at different locations within the pot, and pots were maintained with soils having different percentages of soil moisture over a considerable period of time to determine how accurately the soil moisture content of the soil could be maintained by this method. In all experiments described, unless stated to the contrary, the soil used was a Wooster silt loam with a moisture equivalent of 26.8 per cent. Different species of plants were then grown in the pots with soil moisture contents of 36 per cent ("wet"), 24 per cent ("medium wet") and 15 per cent ("dry"). Data were obtained on the amount and rapidity of growth, time of blooming, number and size of blossoms, and other general growth characteristics of these plants.

In certain experiments the influence of soil mulches and soil modifiers on the utilization of water by plants was investigated. The auto-irrigator pots make it possible to determine whether the increased growth often secured when mulches are placed on soils in which plants are growing or organic matter is incorporated into these soils is due to the effect of the organic matter or to an increased soil water content. The effect of soil modifiers on the water-supplying power of the soil media used was also determined by the soil-point method. Their effect on the moisture equivalent of the soil was also measured. All moisture equivalents were determined by centrifuging soil samples in an International Centrifuge for a period of 40 minutes at a speed of 2440 r. p. m.

<sup>1</sup>This article first appeared in *Abstracts of Doctors' Dissertations*, No. 20. The Ohio State University Press, Columbus, Ohio, 1936.

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<sup>3</sup>1929. *Bull. Torrey Bot. Club* 56: 139, 153.

### UTILITY OF AUTO-IRRIGATOR POTS AS A METHOD OF SOIL WATER CONTROL

The auto-irrigator pots were found to be a suitable means of controlling soil moisture within narrow limits of variation for prolonged periods of time. The maximum variations in water content of the soil in a number of pots were determined. The greatest difference found between the water content of the soil in the outside layer and the center of the pot was 4.2 per cent; the greatest difference between top and bottom layers of soil, 5.1 per cent. The variation in the water content of the soil in any given setup, when this method of soil water control is used, is therefore very small. This variation is not as great as is encountered in the use of the older types of auto-irrigators or by the method of bringing the soil up to a certain weight by the addition of water at given intervals of time. Soils can be held at an approximately constant percentage of soil moisture anywhere within a range from below the wilting point for plants to a condition of soil saturation. These conditions can be maintained as long as the plant is in the auto-irrigator, by simply keeping the reservoirs adequately supplied with water.

Not only are the pots valuable as a means of maintaining a definite soil moisture content, but they are also useful in experimentation wherein the amount of water used by the plant is to be recorded as in water requirement studies. The pots proved to be suitable for use in studies of plants growing in controlled environments in which the water supply is held constant. Differences in the resulting development can then be attributed with more certainty to other environmental conditions. Investigations on the value of mixing peat moss with the soil, using it as a mulch on the soil, and the effect of different soil media on the water-supplying powers of the soil are better accomplished by the use of auto-irrigator pots than by other methods.

### PLANT GROWTH IN RELATION TO SOIL MOISTURE CONTENT

When plants are grown in auto-irrigator pots, usually the plants receiving the greatest amount of moisture in the soil, short of the saturation point, show the best growth. Water in sufficient quantities to saturate all of the soil in the pot or even to saturate the lower half of the soil in the pot was extremely detrimental. Complete saturation caused defoliation and subsequent death of the plants in a relatively short time. The same effect was obtained even when only the lower portion of the soil was saturated, except that death did not ensue so soon.

A consistent decrease was found in weight and height of plants, diameter of flowers and stems, number of flowers per plant, and number of flowering shoots per plant with decrease in the moisture content of the soil (Fig. 1). The results obtained with several of the species of plants used in the investigation are shown in Table 1.

TABLE 1.—Effects of Different Soil Moisture Contents on the Growth of Greenhouse Crops

Crop	Fresh weight in grams							
	Wet			Medium wet			Dry	
	Shoot	Root	S/R	Shoot	Root	S/R	Shoot	S/R
<i>Calendula (Calendula officinalis)</i> .....	178.0	205.0	0.86	96.0	123.0	0.75	94.0	0.76
<i>Cineraria (Cineraria cruenta)</i> .....	182.0	168.0	1.10	156.0	62.0	2.50	148.0	2.40
<i>Carnation (Dianthus caryophyllus)</i> .....	79.0	63.0	1.20	70.0	56.0	1.20	57.0	1.20
<i>Cyclamen (Cyclamen sp.)</i> .....	183.0	160.0	1.20	151.0	81.0	1.80	142.0	2.70
<i>Melior Begonia (Begonia sp.)</i> .....	242.0	138.0	1.70	119.0	98.0	1.20	54.0	0.80
<i>Lorraine Begonia (Begonia boliviensis)</i> .....	524.0	220.0	2.30	365.0	165.0	2.20	129.0	2.00
<i>Chrysanthemum (Chrysanthemum sp.)</i> .....	134.0	.....	.....	117.0	.....	.....	101.0	.....
<i>Pompon Chrysanthemum (Chrysanthemum sp.)</i> .....	39.0	.....	.....	32.0	.....	.....	19.0	.....
<i>Poinsettia (Euphorbia pulcherrima)</i> .....	74.0	.....	.....	65.0	.....	.....	57.0	.....
<i>Snapdragon (Antirrhinum majus)</i> .....	62.0	.....	.....	53.0	.....	.....	31.0	.....
<i>Fern (Boston) (Polypodium sp.)</i> .....	170.0	.....	.....	144.0	.....	.....	116.0	.....
<i>Stocks (Matthiola incana)</i> .....	46.5	10.4	4.40	24.2	5.6	4.30	16.3	3.30
<i>Coleus (Coleus blumei)</i> .....	36.1	14.2	2.50	66.2	40.6	1.60	27.8	1.40

Many diseases of greenhouse flower crops often associated with high soil moisture content are apparently more the result of improper application of the water than of the amount of water applied, as no diseases appeared on the plants in the "wet" pots in any of the experiments conducted as a part of this investigation.



Fig. 1.—*Begonia* growing in "wet" soil, left; "medium wet", center; and "dry", right

Root growth and distribution were governed by the percentage of moisture in the soil. Roots apparently grow only into soils in which the available water supply is adequate.

#### EFFECT OF SOIL MOISTURE ON TIME OF BLOOMING

The length of required time for some species of plants to produce blossoms was found to be affected by the moisture content of the soil in which the plants were grown. The plants grown in moisture-deficient soils throughout their development bloomed later than similar plants grown under more favorable soil water conditions for the same period of time. Deficient soil moisture during the early stages of plant development was found to be more detrimental to reproductive development than a deficiency of water during the later stages of growth.

#### EFFECT OF MOISTURE CONTENT OF THE MEDIUM ON THE ROOTING OF CUTTINGS

As shown in Table 2, the percentage of cuttings rooting in sand decreases with diminution in the water content of the sand. Root initiation, as well as elongation, is dependent on an adequate supply of available moisture.

**TABLE 2.—Percentage of Rooting of Cuttings in Sand Maintained at Different Percentages of Moisture**

Crop	16 per cent moisture	24 per cent moisture	32 per cent moisture
Lorraine Begonias.....	34	100	100
Fuchsias.....	0	43	91
Carnations.....	0	40	86
Chrysanthemums.....	0	37	100

### INFLUENCE OF SOIL MULCHES AND SOIL MODIFIERS ON THE UTILIZATION OF WATER BY PLANTS

A mulch of peat moss applied to the surface of the soil in auto-irrigator pots caused a decrease in growth of the plants rooted in them if the two media were maintained at equal soil moisture contents. Similar results were secured when organic matter in the form of peat moss was mixed with a good compost soil, and the growth of the plants in this mixture compared with the growth of plants growing in the compost alone. These results are in accord with those obtained by other investigators on the incorporation of undecomposed organic materials into agricultural soils. Apparently, if a soil is deficient or low in nitrogen content, the organic matter causes a nitrogen deficiency which is due to the decomposition process. The decomposition or cellulose bacteria are capable of removing nitrogen from the soil more easily than the plants are able to remove it. The results obtained when mulches are applied to soils or organic matter is incorporated with a soil would seem to depend on the state of decomposition of the organic matter, the fertility of the soil, and, to a greater degree, on the manner in which the soil water supply is affected by these materials.

### EFFECT OF INCORPORATION OF ORGANIC MATTER ON THE WATER-SUPPLYING POWER OF SOILS

The water-supplying power of the soil was measured by the soil-point method, as described by Livingston and Koketsu.<sup>4</sup> The incorporation of organic matter in a soil increases its moisture holding capacity, and theoretically would also increase its water-supplying power. Experimental confirmation of this theoretical expectation was obtained by means of such measurements. The increase in water-supplying power, however, was not in proportion to the amount of organic matter added.

### RELATIONSHIP BETWEEN SOIL MOISTURE CONTENT AND SHOOT-ROOT RATIOS

The shoot-root ratios of some of the plants used in these investigations were computed to determine any existing relationship between soil moisture content and the resulting shoot-root ratios. The entire shoot system and entire root system of each plant were dried in an oven at 103° C. as a separate fraction, as a method of determining its dry weight. Results are shown in Table 3.

The data obtained (average from four plants) show that the greater the soil water content, the smaller the shoot-root ratio of stocks. The average shoot-root ratio of the plants growing in "wet" soil was 2.1; of those in "medium wet" soil, 2.5; and of those in "dry" soil, 4.3.

TABLE 3.—Shoot-root Ratios of Plants Grown in Soils Maintained at Different Percentages of Soil Moisture

Species	Shoot-root ratio (dry weight basis)		
	"Wet" soil	"Medium wet" soil	"Dry" soil
Stocks.....	2.1	2.5	4.30
Tomatoes.....	3.1	2.5	2.90
Beans.....	2.5	1.0	0.82

The figures on the shoot-root ratios of tomatoes and beans do not parallel the results secured with the stocks. The tomatoes showed an average (six plants) shoot-root ratio of 3.1, 2.5, and 2.9 in the "wet", "medium wet", and "dry" soils, respectively; whereas the beans (average of six plants) gave 2.5, 1.0, and 0.82 for these same soil treatments. This would seem to indicate that the shoot-root ratios of different species of plants are differently affected by variations in the soil water content within the range used in this investigation.

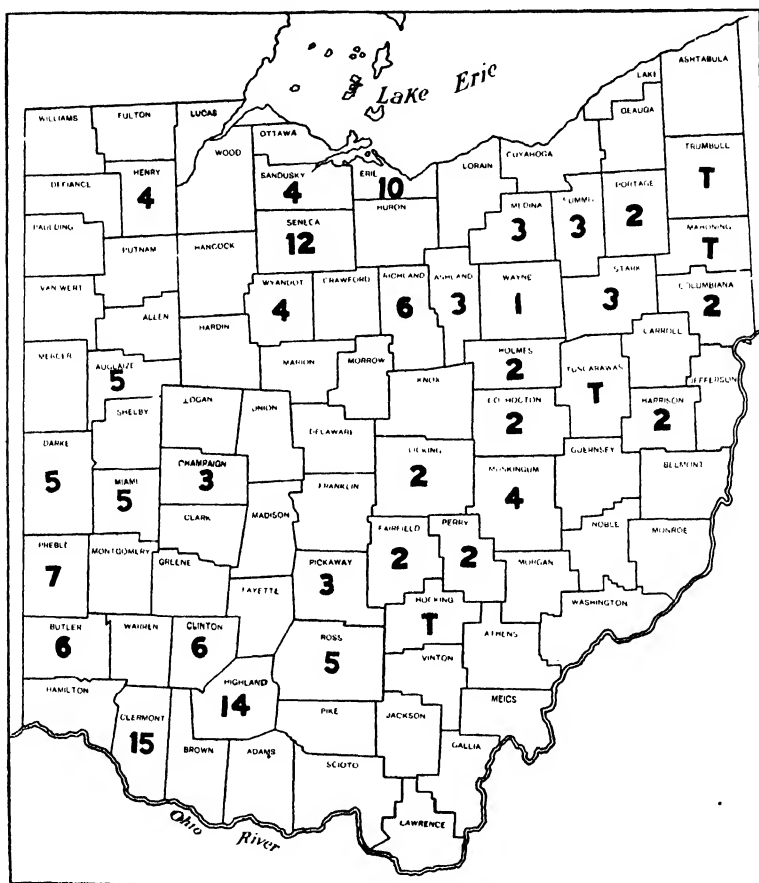
Harris<sup>b</sup> working with wheat found that the shoot-root ratio was larger with a 30 per cent soil moisture than with a 15 per cent soil moisture. With corn seedlings grown for a 5-day period he obtained an increase in shoot-root ratio as the soil moisture was increased from 11 to 38 per cent. Theoretically, an increase in soil moisture, if not excessive, should increase the shoot-root ratios. The results obtained substantiate Harris' results only in some cases.

Inadequate aeration is known to reduce the shoot-root ratio of plants. The most plausible explanation for the decrease in the shoot-root ratio of stocks with increased soil water content is that the roots of this species require better soil aeration than those of the other two species used and, hence, development relative to roots is checked at a lower soil water content than in other species.

<sup>b</sup>1914. Jour. Amer. Soc. Agron. 6: 65-75.

**J. S. HOUSER**

The annual wheat field survey, which has been completed recently through the cooperative efforts of the entomologists of the Extension Division of the State University, the State Department of Agriculture, and the Agricultural



Average infestation in 1937.....	4.4 per cent
Average infestation in 1936.....	12.4 per cent

Experiment Station, indicates that the average infestation for the State as a whole is 4.3 per cent, which is but a little over a third of the percentage infested last year. This figure is based upon critical records taken from the 35 counties visited. Tuscarawas County had the lowest infestation with but two straws affected in every thousand examined, and Clermont, the highest with 150 straws per thousand attacked by Hessian fly. The map, Figure 1, indicates the percentage infestation in the other counties surveyed.

There may be some value at this time in presenting in graphic form the recorded average infestation of wheat in Ohio for each year since the survey was started in 1917. This is shown in Figure 2.

A thoughtful study of this record of the ups and downs of the Hessian fly in Ohio cannot fail to dispel any feeling of false security one might have at this time concerning the ability of this insect to rehabilitate itself quickly following a period of scarcity. The outstanding demonstration of this ability occurred from 1917 to 1920, when the State-wide infestation increased from less than 1 per cent to 44 per cent—the lowest and highest, respectively, that have been recorded. The increase from 12 per cent in 1931 to 35 per cent in 1932 likewise is significant.

Because of the foregoing facts, the cautious farmer will not digress greatly this fall from the recommended fly-free date for his area. For the convenience of those who contemplate sowing wheat this fall a map of Ohio showing the fly-free dates for the various sections of the State is shown in Figure 3.

If early fall growth conditions are favorable, there is a good prospect for a considerable amount of volunteer wheat in fields that were too wet to cut at the proper time and in which wheat later shattered when harvested in the dead-ripe stage. This volunteer wheat constitutes a hazard in fly control about

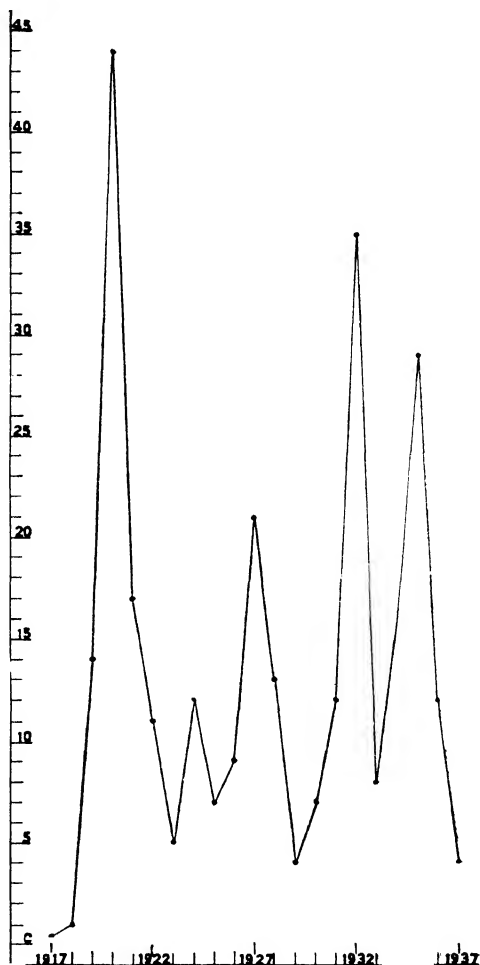


Fig. 2.—Percentage infestation by Hessian fly of wheat in Ohio from 1917 to 1937. The figures at the left indicate percentages.

which there is little to be done in a practical way. However, early sowing would accentuate the situation by affording the fly further opportunity to increase.

Neither of the joint worms which attack wheat was found in numbers of any significance. As was to be expected, because of the heavy rains of the early part of the season, chinch bugs were not found in any abundance in any part of the State. Only a few scattered individuals were observed in some of the fields visited.

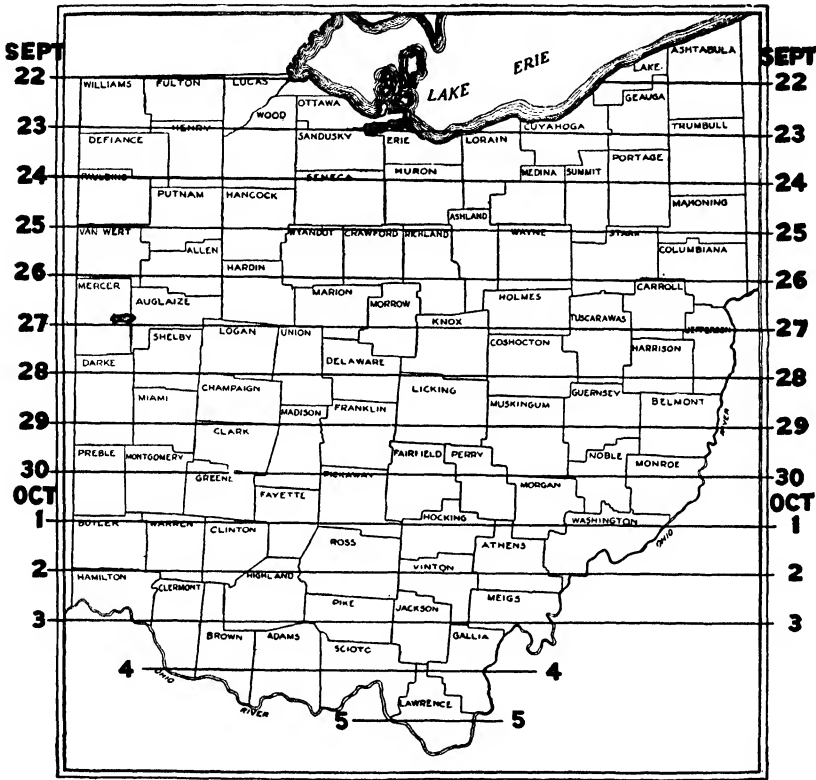


Fig. 3.—Hessian fly-free seeding dates

Armyworms did some damage, particularly in the western part of the State.

Following a suggestion made by Mr. F. J. Udine of the Federal Bureau of Entomology and Plant Quarantine, careful observations were made in southeastern Ohio for the presence of a beetle of the so-called billbug group, *Calendra minima*, which, in the larval stage, feeds within the interior of the lower part of the wheat plant after the plant is somewhat mature. Evidence of its presence was found in a number of fields, particularly in Noble and Washington Counties. One field in Noble County had 8 per cent of the straws examined affected.

The black wheat-stem sawfly situation in the State was given special attention. The findings concerning this insect are recorded in a separate article.

It may be said in general concerning the findings revealed by the survey<sup>1</sup> that with the exception of the black wheat-stem sawfly, the Ohio wheat crop of 1937 was remarkably free from insect damage.

## THE BLACK WHEAT-STEM SAWFLY

J. S. HOUSER

Particular attention was given Ohio's new wheat pest, the black wheat-stem sawfly, during the course of the annual wheat field survey.

It will be recalled that this insect was discovered in Ohio in 1934. Since that time the spread westward has progressed until at present the sawfly is known to occupy an area slightly more than one-fourth that of the entire State.

The outstanding revelation of the survey this year is the amount of new territory added to that formerly known to be occupied. Reference to the accompanying illustration, Figure 1, will demonstrate this point.

The numbers in each county indicate the average percentage infestation of the fields examined. Usually, a random sample of 50 straws from each of 10 fields in each county was used for this survey.

If the infestation records for 1937 are compared with those of 1936 of the counties comprising the more heavily infested area, it will be observed that a decrease in percentage infestation is indicated for this season. It is possible that this is somewhat misleading when considered from the standpoint of the total number of insects present within any given area. As a general rule, the number of wheat straws per acre is much larger this year than last, which may account for the larger percentage of the crop which escaped attack.

A peculiarity in the insect's behavior occurred this year in that progress of the larvae downward toward the base of the plant was delayed until later than usual and that in some fields some of the straws were cut off two or three joints above the base instead of near the soil surface, the usual place. A possible explanation for this digression from normal is that on the average the wheat was much taller than last year.

The percentage of fallen straw was not as large this year as it has been some seasons. On other occasions also it has been observed that thick stands of wheat are less likely to lodge from sawfly attack than are thin stands. This year a larger number of straws than usual were not completely severed by the insect even when harvest was delayed until the dead-ripe stage. This fact, together with the failure of the crop to lodge in the characteristic manner when the sawfly is abundant, created the false impression in the minds of some growers that the insect was not present. Some fields were observed which had very little fallen straw but which had as much as 70 per cent of the straws infested.

The question has been raised whether the presence of this new wheat pest in Ohio wheat fields might not influence adversely the adoption of the combine as a harvesting device. As was indicated in last year's report on this insect, some of the farmers in the more heavily infested area have modified their harvesting practice to the extent that they are cutting their wheat, when possible, slightly in advance of the dead-ripe stage. It is necessary, of course, to wait until the straw is ripe and the grain hard before the combine can be used.

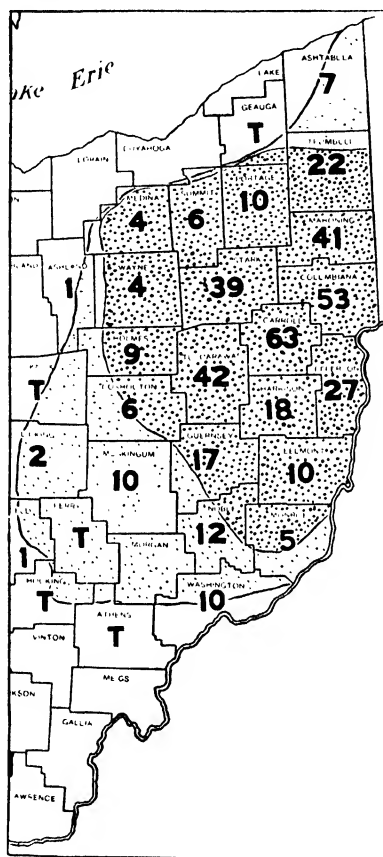


Fig. 1.—The area in Ohio in which the black wheat-stem sawfly is known to occur. The lighter shaded section is that found for the first time this year. The figures indicate the percentage infestation for the county. The letter T signifies less than 1 per cent.

In brief, it may be stated that according to our present knowledge of the sawfly problem, possible losses may be reduced by following those farm practices which produce thick, vigorous stands and by harvesting the grain slightly in advance of the dead-ripe stage.

# THE EFFECT OF BORON, MANGANESE, AND ZINC ON THE CONTROL OF APPLE MEASLES

H. C. YOUNG AND H. F. WINTER

"Measles" as discussed in this report concerns primarily the pimply and internal bark necrotic condition of Red Delicious apple trees. The term "measles" has been applied to many types of apple bark necrosis, some of which differ greatly in appearance and cause; this makes the name ambiguous, and it should, perhaps, be discarded. However, as most Ohio growers recognize the pimply condition of Red Delicious as "measles", and since the term is fairly descriptive for this specific trouble, it was thought best to use it in this report.

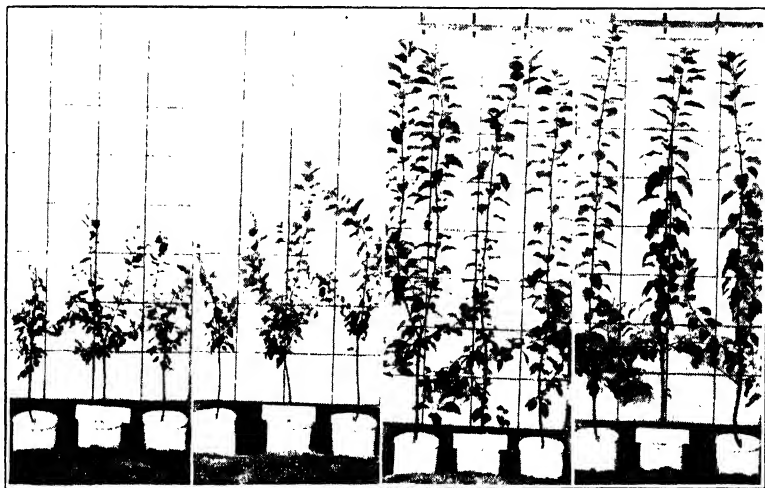


Fig. 1.—Red Delicious apple trees grown in sand culture. The lines on the background are 1 foot apart.

- A—Complete nutrient solution
- B—Complete nutrient plus  $\frac{1}{2}$  ppm of zinc
- C—Complete nutrient plus 1 ppm of boron
- D—Complete nutrient plus 2 ppm of boron

The disease is so common on Red Delicious that it seems unnecessary to give a lengthy description here. It simply manifests itself as small, circular, raised pimples on the outer bark. These pimples vary in size from  $\frac{1}{16}$  inch to  $\frac{1}{8}$  inch or larger. Just under the pimples the phloem region is dark and somewhat disintegrated, resulting in a typically necrotic condition. Trees affected with "measles" make very slow growth, produce large numbers of suckers, and frequently die. Even mildly affected trees rarely produce profitable crops. The disease is most common on Red Delicious and Starking, although it occasionally occurs on other varieties, particularly Jonathan, Stayman, and Rome Beauty. This type of "measles" should be distinguished from the pox types occurring generally in the Ohio valley region.

Repeated efforts were made to isolate a causal agent but none was found. Attempts to transfer the disease by grafting and budding were made, with no success. Buds selected from severely diseased trees gave no more disease than apparently healthy buds. After many years of this type of study it was concluded that perhaps the disease was a result of some physiological disturbance, resulting either from incompatibility of scion and stock or an unbalanced condition of the soil nutrients. Several different fertilizer tests, including complete fertilizer, lime, additional nitrogen, and cover crops of various sorts, were tried. Generally, the results from these tests were negative. There were exceptions, however. Occasionally trees would recover, particularly where complete fertilizer and cover crops were used.

TABLE 1.—The Effect of Boron, Manganese, and Zinc on the Growth of Apple Trees Grown in Sand Cultures\*

Nutrient solution	Diameter of tree in inches at base			Total twig length			Increase of diameter over complete nutrient	Increase of twig growth over complete nutrient
	1936	June 1, 1937	July 20, 1937	1936	June 1, 1937	July 20, 1937		
Complete nutrient solution	0.44	0.47	0.48	54.8	61.0	77.1	Pct.	Pct.
Plus 1 ppm of boron .....	0.51	0.67	0.71	62.0	126.5	160.4	48.0	108.0
Plus 2 ppm of boron .....	0.59	0.72	0.84	62.2	159.3	170.5	75.0	121.1
Plus 1 ppm of manganese†	0.42	0.50	0.51	55.7	64.5	62.0	6.2	.....
Plus ½ ppm of manganese†	0.42	0.47	0.52	52.3	43.3	70.9	8.3	.....
Plus 1 ppm of zinc† .....	0.33	0.43	0.49	39.3	55.5	69.1	.....	.....
Plus ½ ppm of zinc† .....	0.38	0.42	0.46	49.3	55.5	87.1	.....	13.0

\*Data represent the average for each plot.

†The manganese- and zinc-fed trees received 2 and 1 ppm, respectively, during the 1936 season.

The occasional recovery of a tree or a group of trees indicated that possibly the actual cause of the disease might be a deficiency of one or more of the so-called "minor" elements. Several field and pure culture solution tests were set up to determine the effect of boron, manganese, and zinc on control of the disease. The reasons for using the pure culture solution were, first, to be able to standardize all fertilizer conditions by the use of chemically pure salts, distilled water, and purified quartz sand and, second, to grow the trees under controlled conditions from the time they were budded until some sort of results appeared. The culture solution selected was the one devised by Shive<sup>1</sup> and designated R<sub>3</sub>S<sub>3</sub>; it was composed of dihydrogen phosphate, calcium nitrate, magnesium sulfate, and a trace of iron. The formula was used at ½ atmosphere. The trees used were Red Delicious budded from apparently healthy stock to French crab. They were set in the purified sand before the buds had started growth. Seven series of four trees each were arranged as follows: Series 1, complete nutrient solution; Series 2 to 7, inclusive, complete nutrient solution to which were added 1 and 2 ppm, respectively, of boron, manganese, and zinc. The experiment was started April 1, 1936, and the trees were grown in the greenhouse until May 20, when they were moved to the outside. As soon as the trees had become dormant in the fall they were placed in common cold storage over the winter.

<sup>1</sup>See Plant Physiology by Miller, p. 196. McGraw-Hill Book Company.

On March 15, 1937, the entire series was again set up as before, except that the manganese and zinc were reduced to  $\frac{1}{2}$  and 1 ppm, respectively. This change was made because of injury from the stronger concentrations. By July 20, 1937, the results were so indicative that it was decided to take data and conclude the major part of the test.



**Fig. 2.—Portion of trunks of Red Delicious apples grown in sand culture**

- A—From tree grown in complete nutrient, showing pimply condition resembling “measles”
- B—From tree grown in complete nutrient plus 2 ppm of boron. Note healthy bark condition.

## RESULTS

The growth of the trees during the 1936 season varied considerably. Those grown in the complete nutrient solution and with 1 ppm of manganese and zinc, respectively, were fairly normal; whereas those fed 2 ppm of these two elements were stunted and unhealthy. The boron-fed trees were far superior to any of the others.

The contrast in growth between the boron plots and the others was much greater during the 1937 season. This contrast is shown in Figure 1 and Table 1.



Fig. 3.—Longitudinal sections taken from trunks of Red Delicious trees grown in sand culture

- A—Section on left shows pimply, “measled” condition of tree grown in complete nutrient solution. Section on right shows the healthy bark condition of tree grown in complete nutrient solution plus 2 ppm of boron.
- B—Same sections as in A but cut to show on left the internal bark necrosis typical of “measled” trees and on right the healthy internal bark condition of boron-fed trees

Shortly after the trees were set in 1937, pimples were observed on most of them. The pimply condition soon cleared up on the boron-fed trees, and at the conclusion of the experiment the bark was thoroughly healthy and had a greenish-gray appearance typical of the Red Delicious. On the other hand, the number of pimples increased rapidly on all the trees in the other plots. At the conclusion of the test the bark of these trees not only contained pimples, but also had a reddish-brown, somewhat scalded appearance, very similar to that of “measles”. The inner bark showed a typically necrotic condition that could not be distinguished from that of “measles” trees in the orchard. Figures 2 and 3 show the “measles” appearance induced by the lack of boron.

The leaves on the boron-fed trees were more than twice the size of the others. (See Fig. 4).

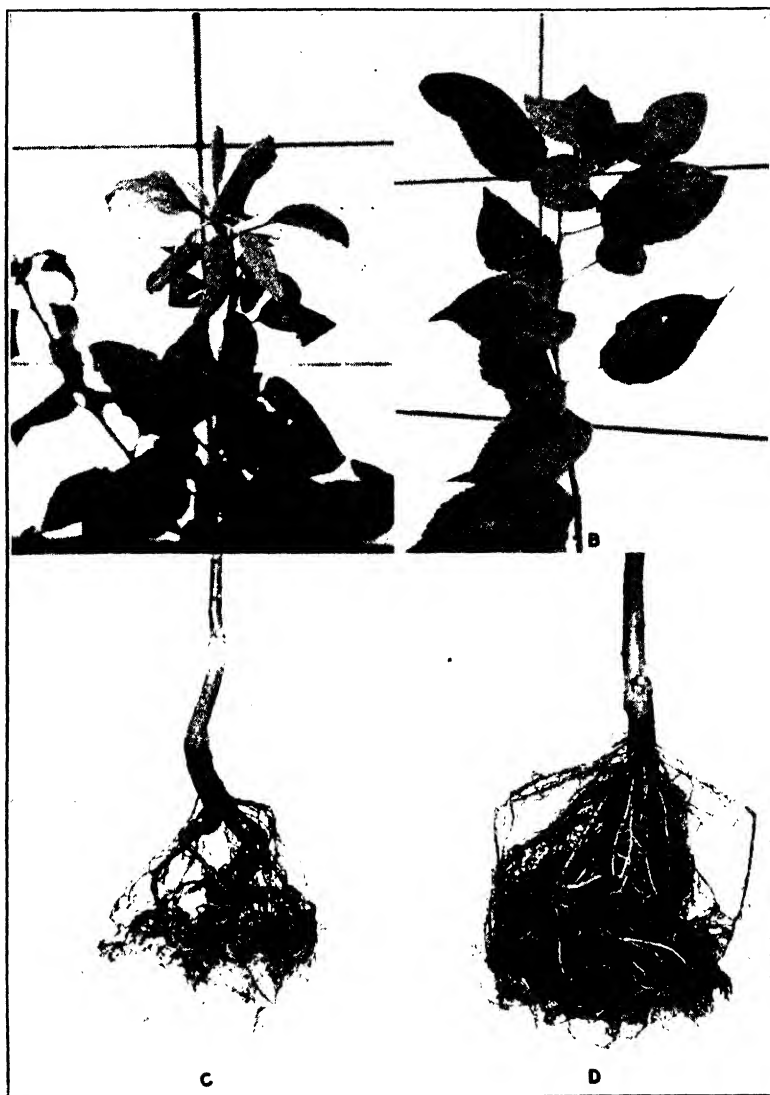


Fig. 4.—Tip portions and roots of Red Delicious apple trees grown in sand culture

- A—From tree grown in complete nutrient solution. Note small leaves and abnormal growth.
- B—From tree grown in complete nutrient solution plus 2 ppm of boron
- C—Root of the same tree as shown in A
- D—Root of the same tree as shown in B

## DISCUSSION AND CONCLUSIONS

The evidence obtained from this test points strongly to the fact that the lack of boron in a growing Delicious apple tree is responsible for much of the condition called internal necrosis. It has not been proved in this work that the pimples and the necrotic condition are identical with "measles" as it occurs in the orchard, but the fact remains that the necrosis induced in these tests cannot be distinguished microscopically or macroscopically from "measles". In this

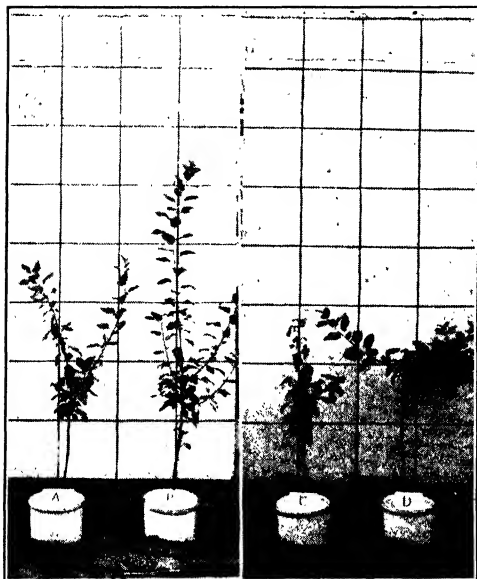


Fig. 5.—Red Delicious apple trees grown in sand culture

- A—Tree on left grown in complete nutrient solution plus  $\frac{1}{2}$  ppm of zinc. Tree on right grown the same, except that 1 ppm of boron was added May 1, or 80 days before the photograph was taken.
- B—Tree on left grown in complete nutrient solution plus  $\frac{1}{2}$  ppm of manganese. Tree on right was grown the same, except that 1 ppm of boron was added May 1, or 80 days before the photograph was taken.

test boron corrected this induced "measles" condition. After the first 6 months all trees showed some pimples; these disappeared in the boron series. Two trees—one complete nutrient, the other complete nutrient plus zinc—showing typical "measles" symptoms were given boron, 1 ppm on May 1, 1937. Figure 5 shows the degree of recovery on July 20.

Not much change was noted for 40 days; then growth and health conditions improved rapidly; and on July 20 the trees appeared thoroughly healthy. Many of the pimples had broken, and the color of the bark was greenish-gray, as on a healthy tree.

The trees fed 2 ppm of boron were slightly better than those fed 1 ppm; hence the limit of boron feeding was not obtained.

The field tests were started later and showed no definite results at the conclusion of the culture tests. No injury had resulted where 1 to 4 pounds of either zinc, boron, or manganese had been applied around trees. The boron treatments were not made until May 15, 1937.

Although no definite recommendations should be made from these results, there seems little likelihood of injury from a moderate application of boron. It is suggested that  $\frac{1}{8}$  to  $\frac{1}{4}$  pound of borax per year of tree's growth be tried on "measles" trees, that is,  $1\frac{1}{2}$  to  $2\frac{1}{2}$  pounds for a 10-year-old tree. It should be emphasized that boron can injure severely and that trees need but a small amount.

# 

J. I. FALCONER

Parity prices for farm products have come to be considered as farm product prices which would give the same purchasing power for farm products as prevailed during the period from 1910 to 1914. In June, 1937, farmers were paying 33 per cent more for the commodities that they purchased than in 1910 to 1914; parity price for farm products would, therefore, be a price 33 per cent above that prevailing in 1910 to 1914.

The accompanying table shows, for several Ohio farm products, the price prevailing in Ohio in June, 1937, and the June parity price. During April, May, and June the price level of Ohio farm products as a whole was at parity; that is, it was 33 per cent above the 1910 to 1914 level. Of the 16 commodities listed six were above parity and nine were below parity; butterfat prices were just at parity. Hay, horses, sheep, and eggs were the commodities farthest below parity; corn, wool, and lambs were the commodities farthest above parity.

TABLE 1.—Price Prevailing in Ohio in June, 1937, and the June Parity Price

	Unit	June, 1937, price	June parity price	Per cent June, 1937, price is above or below parity
		<i>Dol.</i>	<i>Dol.</i>	
Wheat.....	Bu.	1.14	1.31	-15
Corn.....	Bu.	1.14	0.85	+34
Oats.....	Bu.	0.48	0.56	-17
Potatoes.....	Bu.	1.05	0.97	+ 9
Hay.....	Ton	11.50	20.35	-44
Hogs.....	Cwt.	10.80	9.44	+14
Beefcattle.....	Cwt.	9.00	8.25	+ 9
Veal calves.....	Cwt.	8.90	10.04	-12
Lambs.....	Cwt.	9.90	8.21	+20
Sheep.....	Cwt.	3.65	5.32	-31
Wool.....	Lb.	0.35	0.28	+25
Eggs.....	Doz.	0.168	0.228	-28
Chickens.....	Lb.	0.158	0.164	- 4
Butterfat.....	Lb.	0.30	0.298	0
Milk cows.....	Head	58.00	69.80	-20
Horses.....	Head	136.00	216.00	-37
Average.....				0

# INDEX NUMBERS OF PRODUCTION, PRICES, AND INCOME

J. I. FALCONER

The tendency for the level of commodity prices to rise which was quite noticeable from October of last year until March of this year seems to have slowed down after the latter date. From October, 1936, to March, 1937, wholesale prices rose 7.6 per cent; from March to July there was little change.

Present indications are that the cash income to the Ohio farmer from the sale of products for the year 1937 will exceed that of 1936 by at least 15 per cent, and will be equal to that of 1926, which was the best year since 1920.

## Trend of Ohio Prices and Wages, 1910-1914=100

	Wholesale prices, all commodities U. S.	Weekly earnings N. Y. State factory workers	Prices paid by farmers	Farm products prices U. S.	Ohio farm wages	Ohio farm real estate	Ohio farm products prices	Ohio cash income from sales
1913.....	102	.....	101	101	104	100	105	101
1914.....	99	100	100	101	102	102	105	108
1915.....	102	101	105	98	103	107	106	111
1916.....	125	114	124	118	113	113	121	121
1917.....	172	129	149	175	140	119	182	199
1918.....	192	160	176	202	175	131	203	240
1919.....	202	185	202	213	204	135	218	266
1920.....	225	222	201	211	236	159	212	226
1921.....	142	203	152	125	164	134	132	130
1922.....	141	197	149	132	145	124	127	130
1923.....	147	214	152	142	166	122	134	144
1924.....	143	218	152	143	165	118	133	146
1925.....	151	223	157	156	165	110	159	174
1926.....	146	229	155	145	170	105	155	177
1927.....	139	231	153	139	173	99	147	165
1928.....	141	232	155	149	169	96	154	156
1929.....	139	236	153	146	169	94	151	165
1930.....	126	226	145	126	154	90	128	137
1931.....	107	207	124	87	120	82	89	100
1932.....	95	178	107	65	92	70	63	73
1933.....	96	171	109	70	74	59	69	85
1934.....	110	182	123	90	77	63	85	98
1935.....	117	191	125	108	87	68	110	127
1936.....	118	199	124	114	100	74	118	147
1936								
January...	118	195	122	109	87	.....	107	120
February...	118	195	122	109	.....	.....	111	106
March.....	116	198	121	104	.....	74	108	118
April.....	116	195	121	105	100	.....	112	131
May.....	115	195	121	103	.....	.....	110	133
June.....	115	196	120	107	.....	.....	112	136
July.....	118	198	123	115	105	.....	121	189
August.....	119	202	126	124	.....	.....	131	183
September...	119	198	127	124	.....	.....	127	169
October....	119	202	127	121	108	.....	124	164
November...	120	201	127	120	.....	.....	123	158
December..	123	211	128	126	.....	.....	127	160
1937								
January...	125	209	128	131	104	.....	128	151
February...	126	211	132	127	.....	.....	127	141
March.....	128	218	132	128	.....	77	129	157
April.....	128	219	134	130	118	.....	134	170
May.....	127	219	134	128	.....	.....	135	162
June.....	.....	.....	133	124	.....	.....	134	159
July.....	.....	.....	.....	.....	123	.....	.....	.....

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November-December, 1937

No. 189

## Ohio Agricultural Experiment Station

WOOSTER, OHIO, U. S. A.



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## THE 14-INCH DEEP-FURROW WHEAT DRILL TESTS

L. E. THATCHER<sup>1</sup> AND R. D. LEWIS<sup>2</sup>

Tests with a 14-inch, disk-type, deep-furrow wheat drill which places the seed in the bottom of a trench were carried on by the Ohio Agricultural Experiment Station and the Ohio Extension Service for 6 years, 1929 to 1934, inclusive<sup>3</sup>. Tests were conducted for 1 or more years on the Ohio State University farm at Columbus, at the Ohio Agricultural Experiment Station at Wooster, on the Northwestern Experiment Farm at Holgate in Henry County, on the Miami, Paulding, and Clermont County Experiment Farms, and on private farms in Clark, Clinton, Greene, and Montgomery Counties.

The deep-furrow drill was compared with the ordinary 7- or 8-inch grain drill normally operated and also with every other cup closed, to give a 14- or 16-inch row spacing. Different rates of seeding were also employed and, in a few tests, both early and late dates of seeding were included.

The yields obtained at the several locations are given in Tables 1 to 7, inclusive, and summarized in Table 8.

### ACRE YIELDS OF WHEAT SOWN WITH THE DEEP-FURROW DRILL AND THE ORDINARY DRILL

TABLE 1.—Tests at the Ohio State University, Columbus, Ohio

Type of drill	Spacing of rows	Rate of seeding per acre	Yields per acre from normal date of seeding			
			1929	1930	1931	Av.
	<i>In.</i>	<i>Pk.</i>	<i>Bu.</i>	<i>Bu.</i>	<i>Bu.</i>	<i>Bu.</i>
Ordinary .....	7	6	30.8	34.0	48.8	37.9
Ordinary .....	14	6	.....	.....	43.2	.....
Furrow .....	14	6	36.3	39.5	45.8	40.5
Furrow .....	14	5	.....	.....	45.4	.....
Furrow .....	14	3	26.2	39.0	46.7	37.3
Yields per acre from late date of seeding						
Ordinary .....	7	6	31.7	12.2	46.5	30.1
Furrow .....	14	6	29.0	31.4	44.2	34.9
Furrow .....	14	3	.....	17.4	42.8	.....

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<sup>2</sup>Associate Professor of Agronomy, the Ohio State University, Columbus, Ohio, and Agent, Bureau of Plant Industry, United States Department of Agriculture.

<sup>3</sup>Credit is due the following persons who were responsible for initiating or supervising the experiments herein reported: Dr. Harold L. Borst for the Columbus experiments, J. S. Cutler and M. A. Bachtell for the experiments on the outlying district and county experiment farms, and J. A. Slipper for the cooperative farm tests seeded in western Ohio in 1931. The Wooster experiments were in charge of the senior author. The junior author supervised the cooperative farm tests seeded in 1930 and visited practically all of the other outlying tests herein reported.

TABLE 2.—Tests at the Ohio Agricultural Experiment Station, Wooster, Ohio

Type of drill	Spacing of rows	Rate of seeding per acre	Yield per acre from normal date of seeding				
			1931	1932	1933	1934	A v.
	<i>In.</i>	<i>Pk.</i>	<i>Bu.</i>	<i>Bu.</i>	<i>Bu.</i>	<i>Bu.</i>	<i>Bu.</i>
Ordinary .....	7	9	39.0	29.2	41.7	.....	36.6
Ordinary .....	7	6	.....	23.4	43.3	27.9	31.5
Ordinary .....	7	4½	39.0	.....	.....	.....	.....
Ordinary .....	7	3	.....	22.5	44.3	.....	.....
Ordinary ..	14	9	39.2	25.0	37.3	.....	33.8
Ordinary .....	14	6	.....	22.5	38.8	25.7	28.0
Ordinary .....	14	4½	39.5	.....	.....	.....	.....
Ordinary .....	14	3	.....	21.4	39.6	.....	.....
Furrow .....	14	9	43.7	24.7	35.7	.....	34.7
Furrow .....	14	6	.....	23.9	41.0	28.8	31.2
Furrow .....	14	4½	41.1	.....	.....	.....	.....
Furrow .....	14	3	.....	22.2	39.8	.....	.....
Yield per acre from late date of seeding							
Ordinary .....	7	4½	27.0	.....	.....	.....	.....
Ordinary .....	14	4½	30.7	.....	.....	.....	.....
Furrow .....	14	4½	20.4	.....	.....	.....	.....

TABLE 3.—Tests at the Northwestern Experiment Farm, Holgate, Henry County

Type of drill	Spacing of rows	Rate of seeding per acre	Yield per acre from	
			Normal date of seeding 1931	Late date of seeding 1932
	<i>In.</i>	<i>Pk.</i>	<i>Bu.</i>	<i>Bu.</i>
Ordinary .....	8	6*-8†	39.8†	36.7*
Ordinary .....	16	6	37.9	32.3
Ordinary .....	16	3	32.3	.....
Furrow .....	14	6	27.0	34.7
Furrow .....	14	4½	31.0	.....
Furrow .....	14	3	36.4	.....

\*Six pecks.

†Eight pecks.

TABLE 4.—Test at the Clermont County Experiment Farm

Type of drill	Spacing of rows	Rate of seeding per acre	Yield per acre—normal date of seeding			
			1931*		1932	
			Test 1	Test 2	Plowed land	Disked land
	<i>In.</i>	<i>Pk.</i>	<i>Bu.</i>	<i>Bu.</i>	<i>Bu.</i>	<i>Bu.</i>
Ordinary .....	7	6	34.6	27.0	22.5	24.1
Ordinary .....	14	6	27.0	35.5	21.4	20.9
Ordinary .....	14	3	21.5	26.1	19.2	19.4
Furrow .....	14	6	35.1	34.9	21.0	20.1
Furrow .....	14	4½	29.0	31.1	19.5	21.8
Furrow .....	14	3	35.1	25.9	19.4	21.8

\*Two different soil types, Test 1, Rossinoyne soil, Test 2, Clermont silt loam.

TABLE 5.—Tests at the Paulding and Miami County Experiment Farms

Type of drill	Spacing of rows	Rate of seeding per acre	Yield per acre—normal seeding date	
			Paulding County, 1931	Miami County, 1931
	<i>In.</i>	<i>Pk.</i>	<i>Bu.</i>	<i>Bu.</i>
Ordinary .....	7	6	44.8	50.0
Ordinary .....	14	6	42.2	39.5
Ordinary .....	14	3	40.9	42.4
Furrow .....	14	6	38.7	42.0
Furrow .....	14	4½	44.1	44.8
Furrow .....	14	3	41.2	40.3

TABLE 6.—Extension Demonstrations—1931 Crop

Type of drill	Spacing of rows	Rate of seeding per acre	Yields per acre Location of fields and soil types				
			Clark County* W. N. Scarff's Sons farm			Green County Carl Morgan farm, Miami and Brookston soils	Montgomery County Harold Eby farm, Fox gravelly-loam soil
			Bellefontaine soil	Brookston soil	Miami soil		
	<i>In.</i>	<i>Pk.</i>	<i>Bu.</i>	<i>Bu.</i>	<i>Bu.</i>	<i>Bu.</i>	<i>Bu.</i>
Ordinary ..	7	7-8	19.8	32.0	26.0	39.6†	34.4†
Ordinary ..	7	4½-5	19.4	34.0	25.0	32.5	29.5
Furrow ....	14	7-8	18.8	34.7	19.8	38.1	28.7
Furrow ....	14	4½-5	17.9	31.2	25.4	39.1	34.4

\*The soil in the Clark County test increased in productivity across the plots as shown by the yields with the ordinary drill at the normal rate of seeding on Plots 1 and 5. The yields have been corrected for this difference.

†Average of duplicate Plots 1 and 5. Soil very uniform.

TABLE 7.—Extension Demonstrations—1932 Crop

Type of drill	Spacing of rows	Rate of seeding per acre	Yields per acre Location of fields and soil types							
			Franklin County Miami soil	Clermont County Rossmoyne soil	Clark County		Clinton County		Greene County	
					Miami soil	Brookston soil	Miami soil	Brookston soil	Miami soil	Brookston soil
	<i>In.</i>	<i>Pk.</i>	<i>Bu.</i>	<i>Bu.</i>	<i>Bu.</i>	<i>Bu.</i>	<i>Bu.</i>	<i>Bu.</i>	<i>Bu.</i>	<i>Bu.</i>
Ordinary ..	7	8	26.9	21.0	25.4	26.6	22.6	22.5	17.6	19.7
Ordinary ..	7	5	19.2	.....	23.3	22.9	23.0	23.9	16.0	17.9
Furrow ..	14	8	20.5	20.6	19.7	23.3	21.5	19.2	.....	.....
Furrow ..	14	5	19.6	20.8	22.0	22.1	19.6	16.7	15.9	17.1

TABLE 8.—Summary of the Yields of the Ordinary Drill at Two Spacings and of the Deep-furrow Drill Both at a Normal and a Reduced Rate of Seeding per Acre

Type of drill	Spacing of rows	Rate of seeding per acre	Yield per acre Number of comparable tests averaged			
			23	25	12	9
	<i>In.</i>	<i>Pk.</i>	<i>Bu.</i>	<i>Bu.</i>	<i>Bu.</i>	<i>Bu.</i>
Ordinary .....	7-8	6-8	31.2	31.1	28.5	34.4
Furrow .....	14	6-8	29.9	29.8	25.8	31.5
Furrow .....	14	3-5	.....	28.9	25.8	31.3
Ordinary .....	7-8	3-5	.....	.....	26.6	.....
Ordinary .....	14-16	3-5	.....	.....	.....	29.2
Ordinary .....	14-16	6-8	.....	.....	.....	31.7

### COMPARISON OF DRILLS AT UNIFORM NORMAL RATE OF SEEDING OF 6 TO 8 PECKS PER ACRE

All together there were 28 tests in which the ordinary grain drill at a spacing of 7 or 8 inches was compared with the 14-inch deep-furrow drill set to sow 6 to 8 pecks of seed per acre. The average of the 28 tests shows a yield of 31.2 bushels per acre for the ordinary drill and 29.9 bushels for the deep-furrow drill (Table 8). There were nine tests in which the ordinary drill was used with every other feed cup closed so that it spaced the rows 14 or 16 inches apart. The average yields of wheat for the nine tests were as follows: ordinary drill, 7- to 8-inch spacing, 34.4 bushels; ordinary drill at 14- to 16-inch spacing, 31.7 bushels; and the 14-inch deep-furrow drill, 31.5 bushels. There is very little evidence here that the deep-furrow drill was superior to the ordinary drill.

### DOES THE 14-INCH DEEP-FURROW DRILL REQUIRE LESS SEED PER ACRE?

These nine comparisons also included the ordinary drill with every other feed cup stopped and seeding at 3 to 5 pecks per acre. The ordinary drill with a spacing of 14 to 16 inches at the low rate of seeding gave a yield of 2½ bushels less than at a normal rate of seeding; whereas the yield with the deep-furrow drill was as large at the low rate as at the normal rate of seeding. However, it should be noted that the ordinary drill at the normal rate of seeding gave a yield of 2.9 bushels more than the highest yield obtained with the deep-furrow drill for these same nine comparisons (Table 8). The 25 comparative tests show the 14-inch deep-furrow drill giving practically the same yields at both rates of seeding but about 7 pecks less than the ordinary drill at the normal rate.

Before too much weight is given to these results, the crop of 1931 should be studied, because 1931 was a year in which low rates of seeding gave high yields—an exception to the rule. A glance through Tables 1 to 7, inclusive, shows that the low rates of seeding were outstanding in 1931.

Additional light is shed on this phenomenon by the rate of seeding test with wheat at Wooster that year. The results are given in Table 9 compared with the average results for a period of 28 years.

TABLE 9.—Rate of Seeding Wheat Test—Wooster

Rate of seeding per acre	Yield per acre	
	1931	28-year average
<i>Pk.</i>	<i>Bu.</i>	<i>Bu.</i>
4.....	39.1	29.3
6.....	39.4	31.7
8.....	40.0	32.9
10.....	39.0	32.7
12.....	37.3	

The explanation for the large return in 1931 from low rates of seeding in the fall of 1930 lies in the large nitrate nitrogen accumulation in the soil following the drouth of 1930. Rainfall was insufficient to leach out soil nitrates

during 1930 and the early part of 1931; consequently the tillering of wheat was greatly stimulated and even thin rates of seeding produced a sufficient number of heads to make a normal yield in 1931.

### DOES THE DEEP-FURROW DRILL LESSEN WINTERKILLING?

The deep-furrow drill has been tried with some success in the western Great Plains Wheat Belt as a means of reducing the losses from winterkilling. Since the type of winterkilling in the western territory is different from that in the more humid East, the western results cannot legitimately be applied to eastern conditions where heaving is probably the principal cause.

In the West, winter injury to wheat is largely due to very low temperatures, frequently accompanied by strong, dry winds, occurring at a time when the soil is not protected by snow. This results in the killing of the wheat plants through actual freezing. Furrow planting has reduced this damage in some instances by protecting the wheat plants from the wind, by lessening soil drifting, and by keeping soil temperatures somewhat higher. In Kansas, S. C. Salmon of the Kansas Agricultural Experiment Station recorded the temperature in the furrows made by the furrow drill through five winters and found that the temperatures were 3, 14, 2, 6, and 3 degrees higher in the furrows than on the level.

Kieselbach, Anderson, and Lyness of the Nebraska Agricultural Experiment Station in a recent bulletin, "Cultural Practices in Winter Wheat Production", have the following to say regarding the furrow-drill method of planting wheat in Nebraska:

**"Surface vs. furrow-drilling.**—Considerable interest has been shown recently, especially in the western part of the state, in the use of the furrow drill. It was assumed that the furrow drill permitted a lower planting rate and provided and maintained a more favorable seed-bed. Three different types of furrow drills planting at two rates per acre have been compared with a standard surface drill planting at comparable rates in both 7- and 14-inch row spacings during the three-year period, 1930-32. As an average, surface drilling in 7-inch rows yielded 42.1 bushels per acre for both rates of planting. In comparison, surface drilling in 14-inch rows when planted at the thinner rate, 49 pounds per acre, yielded only 87 per cent as much as the 7-inch row spacing. Similar planting, at the heavier rate of 75 pounds per acre, resulted in a yield 93 per cent as great as that from the 7-inch spacing. As an average for the three furrow drills, the thin rate of planting (45 pounds per acre) and the heavy rate (79 pounds per acre) yielded only 77 and 86 per cent as much, respectively, as the standard surface drilling. These results show very clearly that under the conditions of these tests a row spacing of 14 inches is too wide for optimum yields and that such reduction in yield can be but partly overcome by thicker planting rates. In addition to row spacing, other factors appear to be involved in lowering the yields from the furrow drilling. Furrow drilling might, however, be better under less favorable seed-bed conditions."

In the Ohio tests with the deep-furrow drill, there have been no clear-cut instances in which the deep-furrow drill lessened winter injury. At Wooster, where the deep-furrow drill method yielded 2 to 4 bushels more than the ordinary drill method in 1931, the difference was due to the better fall stand obtained on a dry seedbed by the furrow method, which placed the seed in moist soil where prompt germination occurred.

The junior author visited practically all of the plantings made in the fall of 1930 and also observed that somewhat better stands were obtained with the deep-furrow drill because of more favorable soil moisture conditions in the deep furrow. Where larger yields were obtained in 1931 from the deep-furrow method of seeding, the better fall stand rather than any lessened winter injury accounted for the increase. Dry seedbeds are so seldom limiting factors to obtaining stands in Ohio that the purchase of a deep-furrow drill for dry seedbeds alone would hardly seem justified.

A consideration of the type of winter injury suffered by the Ohio wheat crop may help in understanding the limitations of the deep-furrow drill as a means of reducing winter injury. Most of the winter damage to wheat in Ohio occurs during the late winter and early spring and is caused by heaving resulting from alternate freezing and thawing of the soil. Seldom is wheat actually killed by low temperatures in Ohio. Heaving is worse on moist to wet soils than on comparatively dry soils, such as obtain largely in the West. In Ohio, the soil generally is very wet in the late winter and early spring. A trench or furrow in order to be effective in reducing heaving must maintain itself throughout the freezing and thawing period. It is able to do so only if the soil is comparatively dry. Protection from heaving might result from the shading effect of the trench walls; a similar result is obtained from mulching with straw. In practice, the furrows made by the deep-furrow drill in the fall are partly or entirely filled up with soil as a result of frost action, so that they afford comparatively little protection in the spring when it is needed.

The moving in of the soil and consequent covering of the roots may slightly reduce the amount of heaving and may help the heaved plants to reestablish themselves. Although there may be occasional seasons in which the deep-furrow drill method would reduce winter injury in Ohio, in general it is likely to be relatively ineffective.

#### **DOES THE DEEP-FURROW DRILL SAVE ON THE USE OF FERTILIZER?**

Since the 14-inch deep-furrow drill with fertilizer attachment distributes the fertilizer in 14-inch rows rather than in 7- or 8-inch rows, it has been claimed that one-half as much fertilizer may be used with as good results as where the ordinary drill is used, because the individual row in each instance receives the same amount of fertilizer.

There are no critical experiments reported by agricultural experiment stations and wherein all factors are controlled that support this contention. It is well known that it takes a certain amount of plant food per acre to produce a given yield of wheat. Since the wheat plants in both the 14-inch and 7- or 8-inch rows fully occupy the land, it is inconceivable that the efficiency of the fertilizer would be doubled by drilling it in 14-inch rows. It would be just as reasonable to assume that a dairy cow would produce as much milk if her feed consumption were reduced by one-half by feeding her only once a day rather than twice a day.

#### **WHAT EFFECT DOES THE DEEP-FURROW DRILL HAVE ON THE STAND OF CLOVER OR GRASS SEEDS IN THE WHEAT?**

In some years the grass and clover have seemed to be slightly better in the furrow and in other years, inferior, especially when grass and clover seedlings that became established were mostly in the rows of grain and not scattered in the intervening spaces.

### OTHER LIMITATIONS OF THE DEEP-FURROW DRILL

The deep-furrow drill has not been satisfactory for seeding oats on disked land or on plowed land that was moist enough to be described as "sad" (a condition frequently met with at oats seeding time) because of the poor seed coverage obtained.

A comparatively mellow, loose, and dry seedbed is needed in order to get good depth and seed coverage with the deep-furrow drill. Since the grain drill on Ohio farms is used for sowing many crops other than wheat, it would seem that the ordinary grain drill has certain advantages over the deep-furrow drill, because the ordinary drill may be operated successfully over a wide range of soil and seedbed conditions.

On sloping land soil erosion is likely to be accelerated where the deep-furrow drill is operated up and down the slope. Contour drilling should be practiced under such circumstances.

Another real objection to the deep-furrow drill (as expressed by farmers on whose farms the tests were conducted) has been the roughness of the furrowed land over which binders, mowers, and other equipment were used.

## FARM PRODUCTS PRICES AND LAND VALUES

H. R. MOORE

The true value of agricultural land is the present worth of all future net income from the land. Whereas no one knows what the future net income may be, the tendency is to capitalize current income, which in turn is dependent on the current price level of farm products, a point illustrated by the lines drawn on the chart in Figure 1. This chart portrays the relationship of farm products prices and land values over a period of more than a half century.

The land values index used in Figure 1 is the relative price derived from the average per acre consideration (other than \$1.00) named in all deeds to agricultural lands recorded in the various years. This index has the merit of representing values annually over a longer period of years than the index of land values currently published on the back page of the Bimonthly Bulletin. It can be criticised in that prevalence of sheriffs' sales following periods of depression, as since 1933, causes the average consideration named in deeds to be temporarily out of line with prevailing land values.

It is an interesting circumstance that Ohio farm land values were practically the same in 1900 as in 1880, trebled from 1900 to 1920, and diminished about three-fifths from 1920 to 1933. In times of prosperity when farm products are high in price the tendency is to bid land prices too high; in times of depression the reverse is true. This instability of land values is detrimental to the permanent well-being of agriculture. When values are declining as they were from 1920 to 1933, the mortgage credit structure is weakened and farm foreclosures and bankruptcy become serious; when values rise too high the generation of farmers then attempting to purchase land must sacrifice financial security and lower the standard of living in order to purchase land. Thus, either too high or too low land prices lessen the security of tenure of the farm population.

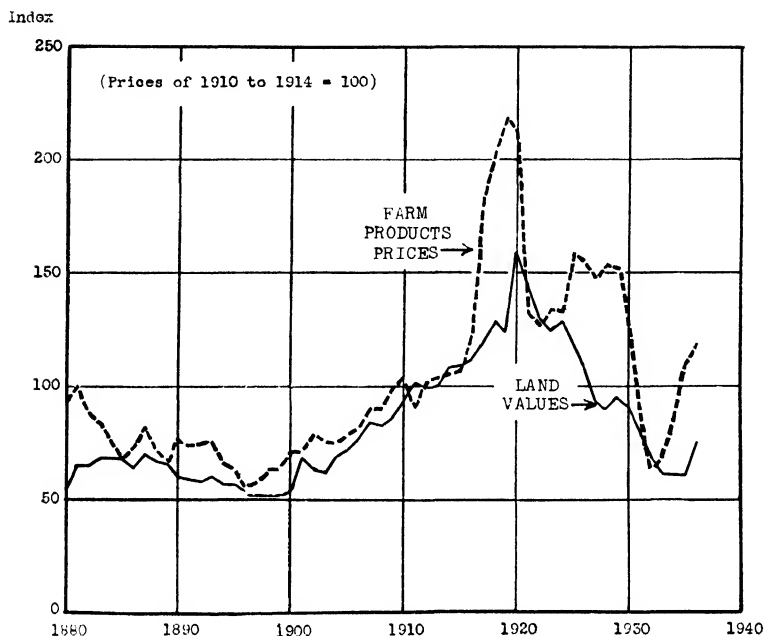


Fig. 1.—Relative farm products prices<sup>1</sup> and land values<sup>2</sup> in Ohio, 1880 to 1936

The present rise in land prices justifies a certain amount of optimism which should be tempered by the hope that the unfortunate circumstances of a land boom are not in the making. More recent data than those plotted in Figure 1 indicate that land prices, although rising, are still below the 1910-1914 level, which, as generally viewed, was a period of normal agricultural prosperity. Whether the future trend in land values parallels the gradual rise prevailing in 1900 to 1910 is primarily dependent on the trend in commodity prices; up to the present time the recent rise in both has been much steeper than prevailed following the year 1900. The average price per acre of farms sold voluntarily the first 6 months of 1937 was 34 per cent higher than the price the first 6 months of 1933, which was presumably the low point in the land price cycle.

<sup>1</sup>Based on the average annual prices of the principal agricultural commodities.

<sup>2</sup>Based on the consideration (other than \$1.00) named in deeds to agricultural lands, reported annually by county recorders to the Secretary of State.

# INDEX NUMBERS OF PRODUCTION, PRICES, AND INCOME

J. I. FALCONER

Ohio farm product prices have regained the levels of the first part of the year 1930, but are still 10 per cent below the prices which prevailed in 1929. As compared with August 1 year ago, the index of prices of Ohio farm products has advanced 3 per cent; whereas the index of products which farmers buy has advanced 5 per cent.

Based upon the income for the first 8 months of the year, it would now appear that the cash income of Ohio farmers from the sale of products for the year 1937 will exceed that of 1936 by between 10 and 15 per cent.

## Trend of Ohio Prices and Wages, 1910-1914=100

	Wholesale prices, all commodities U. S.	Weekly earnings N. Y. State factory workers	Prices paid by farmers	Farm products prices U. S.	Ohio farm wages	Ohio farm real estate	Ohio farm products prices	Ohio cash income from sales
1913.....	102	.....	101	101	104	100	105	101
1914.....	99	100	100	101	102	102	105	108
1915.....	102	101	105	98	103	107	106	111
1916.....	125	114	124	118	113	113	121	121
1917.....	172	129	149	175	140	119	182	199
1918.....	192	160	176	202	175	131	203	240
1919.....	202	185	202	213	204	135	218	266
1920.....	225	222	201	211	236	159	212	226
1921.....	142	203	152	125	164	134	132	130
1922.....	141	197	149	132	145	124	127	130
1923.....	147	214	152	142	166	122	134	144
1924.....	143	218	152	143	165	118	133	146
1925.....	151	223	157	156	165	110	159	174
1926.....	146	229	155	145	170	105	155	177
1927.....	139	231	153	139	173	99	147	165
1928.....	141	232	155	149	169	96	154	156
1929.....	139	236	153	146	169	94	151	165
1930.....	126	226	145	126	154	90	128	137
1931.....	107	207	124	87	120	82	89	100
1932.....	95	178	107	65	92	70	63	73
1933.....	96	171	109	70	74	59	69	85
1934.....	110	182	123	90	77	63	85	98
1935.....	117	191	125	108	87	68	110	127
1936.....	118	199	124	114	100	74	118	147
1936								
January...	118	195	122	109	87	.....	107	120
February...	118	195	122	109	.....	.....	111	106
March.....	116	198	121	104	.....	74	108	118
April.....	116	195	121	105	100	.....	112	131
May.....	115	195	121	103	.....	.....	110	133
June.....	115	196	120	107	.....	.....	112	136
July.....	118	198	123	115	105	.....	121	189
August.....	119	202	126	124	.....	.....	131	183
September..	119	198	127	124	.....	.....	127	169
October.....	119	202	127	121	108	.....	124	164
November...	120	201	127	120	.....	.....	123	158
December...	123	211	128	126	.....	.....	127	160
1937								
January...	125	209	130	131	104	.....	128	151
February...	126	211	132	127	.....	.....	127	141
March.....	128	218	132	128	.....	77	129	157
April.....	128	219	134	130	118	.....	134	170
May.....	127	219	134	128	.....	.....	135	162
June.....	127	220	134	124	.....	.....	134	160
July.....	128	218	133	125	123	.....	138	191
August.....	128	.....	132	123	.....	.....	135	169

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<sup>1</sup>In cooperation with College of Agriculture, Ohio State University.

<sup>2</sup>In cooperation with the U. S. Department of Agriculture.

## NEW MONOGRAPH BULLETINS

**Bulletin 580. Cultural Systems for the Apple in Ohio**, by C. W. Ellenwood and J. H. Gourley. It is the purpose of this bulletin to examine the effects of the various systems of orchard culture in use in Ohio upon the soil and trees. The authors discuss the sod, tillage, and mulch systems of soil management and their effects upon yield, color and size of fruits, growth and size of trees, and date of bloom. They compare growing costs under these systems, and show how the root systems of apple trees are affected by cultural treatments. The bulletin also contains suggested practices for Ohio orchards.

**Bulletin 581. Peach Production in Ohio**, by Leon Havis and J. H. Gourley. This bulletin brings to the orchardists and prospective orchardists of Ohio information regarding the culture of peaches. It stresses the more practical aspects of peach production but includes reports of certain experiments and refers to others. Some of the topics the authors take up are propagation, varieties, securing and caring for young trees, orchard planting and management, harvesting, and marketing. They also discuss in detail fertilizers for the orchard. The bulletin includes a report on root distribution studies.

**Bulletin 582. Population Mobility in Selected Areas of Rural Ohio, 1928-1935**, by C. E. Lively and Frances Foott. The data of this bulletin were drawn from a field survey of 2554 rural households located in 10 rural townships and in eight villages. The mobility of the resident population and of adult children away from the parental home was obtained; emphasis was placed upon the movements during the period, January 1, 1928, to January 1, 1935.

**Bulletin 583. Codling Moth Biology and Control Investigations**, by C. R. Cutright. The text of this bulletin is a summary of over 10 years of work with the codling moth. It points out principles fundamental to codling moth biology and control. The bulletin contains discussions of codling moth biology in various parts of Ohio, of the effect of weather on codling moth scarcity or abundance, and of special phases of codling moth biology. It takes up in detail experiments in codling moth control, including spraying with different materials and supplementary control measures.

**Bulletin 584. Removal of Spray Residue from Apples**, by C. W. Ellenwood, V. H. Morris, and E. A. Silver. This bulletin presents the results of the spray residue work undertaken in 1935 and 1936. An effort was made in this work to determine the probable amounts of residue that result from a number of different spray programs commonly used in Ohio and to determine the effectiveness of methods and equipment which have already become more or less standard in removing spray residues. In presenting data, the authors have kept in mind their possible practical value to the apple growers of Ohio.

**Bulletin 585. The Effect of Land Use and Management on Erosion**, by E. H. Reed and J. I. Falconer. This bulletin presents the results of a study, the purpose of which was to determine in a limited area some of the factors within the control of man which had contributed to erosion. This study points out the importance of quality of farming and management, as well as organization and land use, as factors in erosion control.

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## Ohio Agricultural Experiment Station

WOOSTER, OHIO, U. S. A.



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**The native forest at the Experiment Station,  
a part of the forest arboretum**

# MAKING SILAGE FROM HAY CROPS

A. E. PERKINS, C. C. HAYDEN, C. F. MONROE, W. E. KRAUSS, AND R. G. WASHBURN<sup>1</sup>

Corn silage has been made and used in this country for approximately 50 years, and practices regarding it have become fairly well understood and standardized. It is only within the past 5 years, however, that the silo has been used to any considerable extent for storing the crops which are more commonly made into hay.

Naturally, not many of the details of the method have as yet been thoroughly studied, and many divergent ideas prevail as to the best practice to follow. There is no age-old body of experience to determine farm practice, as in the case of haymaking; and practice is very likely to be determined largely by the outcome of experimentation.

In some other parts of the world considerable progress has been made in the ensiling of miscellaneous crops. We are thus able to draw to some extent on the published experiments and experience of others when the conditions are comparable to those under which we are working.

## THE CROPS

Most of the leguminous crops commonly grown for hay in Ohio, such as alfalfa, various kinds of clover, soybeans, sweet clover, peas, or vetch, have been ensiled successfully. These legumes contain on the average more protein and less soluble carbohydrates or sugars than corn or some of the other cereals and grasses, though the legumes contain considerable amounts of soluble sugars and are not so greatly different from others of the grasses and cereals in this respect. These relations for some of the more common crops are shown in Table 1, which is taken from the work of Wilson and Webb (1) of the New York (Cornell) Experiment Station. Only a few of the more common crops are shown in this table. A great variety of grasses, weeds, and other classes of plants have also been ensiled successfully and may be utilized for silage if available in sufficient quantity. In the case of most such plants, however, it is doubtful whether they would be better adapted for cultivation as silage crops than the plants already in use. Frequently a damaged or weedy stand which was originally intended for other purposes may be best utilized as silage, for the weeds or other imperfections are usually less objectionable in the silage than in hay or other marketable forms of the product. From the standpoint of quality of the resulting silage, however, it is probable that silage prepared from material grown for the purpose and harvested at the proper time will often be preferable to that prepared without reference to the best time of harvest merely as a means of salvaging some other crop.

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<sup>1</sup>The writers are indebted to Mr. S. A. Powers for making the drawing shown as Figure 2.

The crops mentioned herein were produced by the Department of Agronomy of the Ohio Agricultural Experiment Station.

1. 1987. *Journal of Dairy Science* **XX**: 247.

TABLE 1.—Percentage of Water-soluble Carbohydrates in Various Plants (Wilson and Webb—Cornell)

Crop	Stage	Sugars (dry basis)	Crop	Stage	Sugars (dry basis)
Barley.....	Heading	11.06	Alfalfa .....	Early silage	4.32
Bluegrass .....	Early seed	5.94	Alfalfa .....	Early bloom	4.26
Buckwheat .....	Bloom, early seed	6.16	Clover, red .....	Begin to seed	9.92
Corn, field .....	Milk stage	20.25	Clover, alsike.....	Begin to seed	5.19
Corn, sweet.....	Roasting ear	28.60	Clover, late, red..	Before bloom	7.11
Rye .....	Setting seed	13.21	Clover, white, sweet .....	Early bloom	6.23
Oats.....	Heading	9.93	Clover, yellow, sweet .....	Full bloom	6.85
Wheat.....	Setting seed	12.92	Cowpea.....	Early bloom	6.55
Timothy .....	.....	8.32	Soybean.....	Pods mature	5.16
Sudan grass.....	Seed milk stage	13.41	Vetch .....	Full bloom	10.32
Millet .....	Seed	4.75			

To get three cuttings from a stand of alfalfa without injuring the future prospects of the stand, Ohio agronomists advise removing the first cutting on or before June 10. Frequently, as in 1935 and 1937, this comes at a period of rainy or showery weather when it is next to impossible to make an acceptable quality of hay. Often the crop is a complete loss. A similar condition frequently prevails at the time of making late cuttings of hay, particularly soybean hay. Being able to save such crops easily and in good condition in the silo should often be a real help to the dairy farmer. If at the same time a feed of superior quality can be obtained which conserves valuable properties destroyed in haymaking, the preparation of hay silage should rapidly become a recognized and stable feature of farm practice.

### TREATMENTS IN THE PREPARATION OF HAY SILAGE

Various treatments have been proposed for hay crops in the preparation of silage. The treatments most commonly advocated are:

1. The addition of molasses or other form of carbohydrate. This treatment is assumed to provide material needed in the fermentation which results in the formation of lactic and acetic acids. The molasses added beyond that used in the fermentation probably serves to increase the food value and palatability of the silage, though definite data in proof of this statement are largely lacking. The cost of adding molasses is relatively low, and since it probably improves the silage in other ways, it is not wholly a dead charge for preservation as are some of the other treatments. The use of molasses in the preparation of hay silage is being advocated by manufacturers of silo-filling machinery in preference to other treatments or no treatment. It is easily the most popular and widely used of the various proposed treatments. Our early work with molasses silage, especially the analysis of that made at other places, did not show very good carotene preservation. In our recent experiments, however, much better carotene preservation has been obtained.

2. The addition of mineral acids in sufficient amount to reduce the pH of the resulting silage below 4.0. This treatment is designed to prevent most of the fermentation and preserve the carotene. Hydrochloric and sulfuric acids, which have no food value in themselves, have most commonly been used in the

past for this purpose. The cost of treatment with these acids in the prescribed proportion is high. Material, freight, and labor costs will probably total approximately \$1.50 per ton of green crop, aside from any royalty which will need to be paid to the patentees of the process. The acid treatment seems to be effective and dependable under most conditions so far as the preservation of the carotene or vitamin A content of the crop is concerned.

The use of phosphoric acid instead of hydrochloric and sulfuric acids for silage treatment is being studied. It is thought that this acid will serve the triple purpose of preserving the silage (including the carotene), furnishing needed phosphorus in the cow's ration, and increasing the fertilizing value of the manure. If a sufficiently pure source of phosphoric acid is developed at a favorable price, this may be a coming process.

3. Treatment of the crop with "dry ice" or solid carbon dioxide. This treatment is also designed to eliminate the fermentation. A special type of silo is said to be required, and the treatment is likely to be otherwise expensive and adds nothing to the food value. This process is still very much in the experimental stage and has not been shown to possess advantages greater than some of the other treatments.

4. No treatment. It has long been known that a good grade of silage can be made from legumes alone, or better still, from legumes mixed with various cereals or grasses. It has repeatedly been shown by experiment that the quality of the silage made by this method is greatly improved by partial drying, if necessary, to bring the dry-matter content above 30 per cent. However, the dry-matter content must not be so high that the material fails to pack well, for the air must be largely excluded to prevent excessive fermentation and decay.

When these simple requirements have been met we have rarely been able to recognize any particular difference in quality between silage made without treatment and that made by the addition of various amounts of molasses. In this respect our work checks very closely with that of Woodward of the Bureau of Dairying (2). Silage in the lowest range of dry-matter content prepared without treatment, however, is likely to be of poor quality and palatability and have a strongly offensive odor.

Because the range of dry-matter content for the successful making of untreated silage is probably smaller than in the case of molasses or acid treatment, and no simple means of dry-matter determination is available to the farmer, equipment manufacturers and other agencies promoting the preparation of legume silage recommend the molasses treatment almost exclusively. To offset what is said to be a pronounced tendency among farmers in some sections to ensile hay crops too dry, the general advice is given to ensile crops at any stage of maturity as wet as possible. For reasons set forth in other parts of the present publication, that particular advice is considered unfortunate under certain conditions.

### IMPORTANCE OF DRY-MATTER CONTENT IN THE PROPER MAKING OF SILAGE

As suggested above, the dry-matter content of a crop is probably the most important consideration to be taken into account in determining the quality of the resulting silage and the procedure which should be followed in its preparation.

In Table 2 will be seen a comparison of A. I. V., or acid-treated silage, made in Ohio and in Switzerland. The low dry-matter content shown here for the Swiss crop seems to be typical of much of the grass silage prepared throughout western Europe, judging by published reports. An average period of only 2 or 3 hours had elapsed between cutting and ensiling the Ohio silage; so no great amount of drying had occurred. The dry-matter content of the standing crop was 25 per cent; that at the silo, 31 per cent.

TABLE 2.—Comparative Data on A. I. V. or Acid Silage under American and European Conditions

	Ohio 1935 data	Steiner European data
Weight of forage ensiled, tons.....	59.50	11.4
Dry matter, per cent.....	31.40	12.5
Double normal acid per ton, liters.....	75.70	78.2
Loss of juice per ton, liters.....	9.60	415.0
Loss of nitrogen in juice, grams per ton of forage.....	12.00	311.0
Per cent of total nitrogen lost in juice.....	0.17	3.0 to 8.6

The loss of juice shown for the European silage of 12.5 per cent dry-matter content was 46 per cent of the weight of the green material. This loss would doubtless have been even greater if the material had been ensiled in one of the larger and deeper silos commonly used in this country. This is exactly what will often be encountered if the advice given in some commercial pamphlets, to ensile "as wet as possible", is followed literally. In addition to the heavy loss of food material derived from the plant itself and carried away in the juice, a large part of the added molasses, which is of course very soluble, will likewise be carried away. Some may object at this point that their silos are watertight and, hence, will retain all the juice. To this contention reply should be made that silage drowned in surplus juice is usually of very poor quality. The obvious practical remedy is to adjust the dry-matter content of the ensiled material so that there will be no loss of juice, or silage super-saturated with juice.

From data regarding the cross-sectional area of the silos used here at this institution and the weight of material ensiled in them it may readily be figured, assuming that the pressure at any given point within the silo is equal to the weight of the material above it, that the pressure near the bottom of a silo filled to a depth of 26 to 28 feet with hay silage of about 30 per cent dry-matter content will be about 8 pounds per square inch. If wetter material is ensiled, if the silo is filled more slowly or to a greater depth than indicated, or if the silo is refilled after settling, the pressure near the bottom may rise to around 12 or more pounds per square inch. Of course, the pressure gradually tapers off to near zero at the surface of the silage. The pressure will be somewhat less with corn, which does not make so compact a silage.

The apparatus shown in Figure 1 was developed at this institution to measure the loss of juice that may be expected from materials of different dry-matter content subjected to different known pressures. The apparatus is almost self-explanatory. A weighed amount of the chopped material, whose dry-matter content is also separately determined, is packed in the chamber of

## MAKING SILAGE FROM HAY CROPS

the apparatus. Weights are applied to the suspended platform, which in turn transmits the weight uniformly over the surface of the silage. There is a drain in the bottom of the chamber, and a container is suspended beneath to catch the juice which runs away. The juice is then measured.

Table 3 shows data obtained by the use of this apparatus regarding hay crops cut at different times, their dry-matter content, and the measured loss of juice at different pressures. At a dry-matter content of 18 per cent, the weight of juice lost at a pressure of 8 pounds per square inch was 30 per cent of the weight of the green crop. There was a loss of 20 per cent of juice even at a pressure of 4 pounds.

At a pressure of 8 pounds the loss of juice for a sample of 21 per cent dry matter was reduced to 12 per cent; whereas a sample of 30 per cent dry matter lost no juice. A comparison between the third and fourth lines of Table 3 shows something of the effect of wetting with rain on the dry-matter content and loss of juice. The sample in Line 4 was taken from the same field as Sample 3, 1 week later. It was taken about 10 A. M. after rain the previous night. The dry-matter content under these conditions was reduced from 30 to 20 per cent, and the loss of juice at a pressure of 8 pounds was increased from nothing to 24 per cent.

A comparison of Lines 5 and 6 in Table 3 will show in a similar manner the effect of wetting with dew on dry matter and loss of juice. The former was decreased 5 per cent, and the latter, increased threefold. It is easy to see that if the material of 18 per cent dry matter previously considered had been ensiled at once when wet with rain or dew, the dry-matter content would have been reduced to around 12 to 13 per cent or less, and the loss of juice, increased accordingly.

Table 4 shows in a similar way the relationship between stage of growth, dry-matter content, and loss of juice in ensiling corn. Minor inconsistencies and variations from the general trend will be noted in these data. They are probably due to other and unrecognized factors, but all silage having below 20

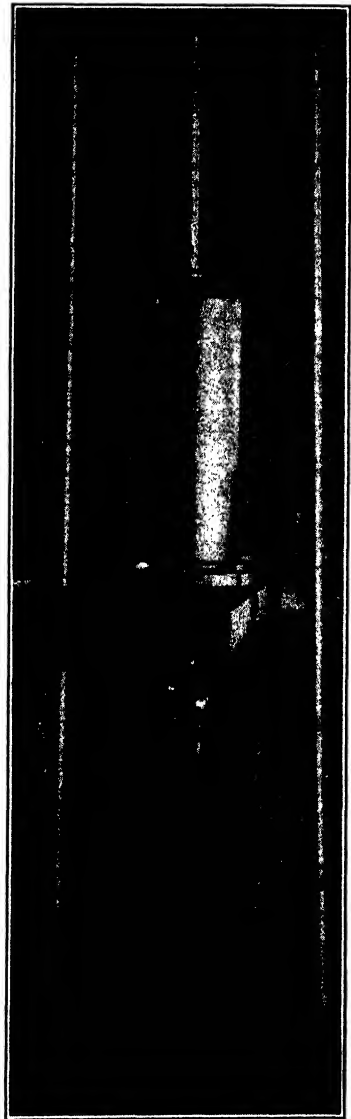


Fig. 1.—Apparatus for studying the relationship between dry-matter content, pressure, and loss of juice in ensiled material

# OHIO EXPERIMENT STATION: BIMONTHLY BULLETIN

## TABLE 3.—Dry-matter Content and Loss of Juice

Material	Date 1937	Dry matter, per cent	Total loss of juice at different stated pressures per square inch Per cent of sample lost			
			16 lb.	12 lb.	8 lb.	4 lb.
1. Clover-alfalfa .....	6/8	18	.....	.....	30.0	20.0
2. Clover-alfalfa .....	7/3	21	.....	.....	12.0	1.2
3. Clover-alfalfa .....	7/7	30	.....	2.8	none	none
4. Clover-alfalfa, from same field as Sample 3, but wet after rain .....	7/14	20	.....	29.0	24.0	12.0
5. Alfalfa, second cutting .....	7/27	28	.....	.....	6.7	.....
6. Alfalfa, second cutting, from same field as Sample 5, the following morning when wet with dew .....	7/28	23	.....	.....	19.6	.....

## TABLE 4.—Dry-matter Content and Loss of Juice in Corn Ensiled at Various Stages

State of corn	Dry matter	Percentage loss of juice at different pressures Pounds per square inch						
		16	12	10	8	6	4	2
Tasseled .....	16.7	.....	40	.....	.....	.....	16	.....
Tasseled .....	18.0	.....	33	.....	22.0	.....	9	.....
Tasseled* .....	16.0	.....	.....	.....	27.0	.....	15	8
Silked .....	17.0	.....	30	.....	25.0	.....	12	4
Silked .....	17.0	.....	28	24	20.0	.....	5	.....
Milk .....	18.0	.....	22	.....	15.0	.....	4	.....
Milk .....	19.6	.....	32	.....	.....	16	.....	.....
Dough .....	21.0	.....	.....	6	4.5	.....	none	.....
Dough .....	23.0	.....	15	.....	7.0	.....	.....	.....
Glazed .....	25.0	17	15	.....	6.0	.....	.....	.....
Glazed dented .....	27.0	.....	10	.....	.....	none	.....	.....
Glazed dented .....	28.0	.....	2	.....	none	.....	.....	.....
Ensiling stage .....	30.0	.....	none	.....	.....	.....	.....	.....
Ensiling stage .....	31.0	.....	none	.....	.....	.....	.....	.....
Somewhat dry .....	35.0	.....	none	.....	.....	.....	.....	.....

\*Wet with dew.

## Table 5.—Dry-matter Content of Various Silage Crops, Per Cent From Wilson and Webb (Cornell)

Crop	Stage	Dry matter, per cent	Crop	Stage	Dry matter, per cent
Corn .....	Milk stage	22.4	Alfalfa .....	Early silage, 6/14	22.9
Corn (sweet) .....	Roasting ear	19.3	Alfalfa .....	Begin to bloom	25.5
Oats .....	Heading	23.9	Red clover .....	Begin to seed	24.8
Rye .....	Setting seed	41.2	Alsike clover .....	Begin to seed	21.0
Barley .....	Heading	21.9	Late red clover .....	Before bloom	20.3
Sudan grass .....	Seed milk	29.6	White sweet clover .....	Begin to bloom	22.0
Millet, early .....	In head, before bloom	12.7	Yellow sweet clover .....	Full bloom	25.0
Millet, common .....	In seed	29.5	White clover .....	Full bloom	18.1
Timothy .....	Late bloom	29.7	Peas .....	Full bloom	17.3
Timothy .....	Before bloom	21.5	Vetch .....	Full bloom	25.1
Bluegrass, Canada .....	Early seed	34.8	Soybeans .....	Pods mature	29.0
Orchard grass .....	Blooming	30.0			

per cent of dry matter lost heavily of juice even in the lower range of pressures.

Samples containing around 25 per cent of dry matter lost juice only at the higher range of pressures; whereas samples of 30 per cent or higher dry-matter content lost no juice at any pressure applied. The loss of juice in relation to dry-matter content is seen to be closely parallel to that observed in the hay silage.

Table 5, also copied from the work of Wilson and Webb, shows one or at most two determinations of dry-matter content on a number of crops judged to be in condition for making silage. Comparative data in one or two cases would indicate that these data were secured in a relatively dry season. Similar but more detailed study of the common crops most likely to be ensiled is needed. These studies should be carried on under different conditions of maturity and weather.

Table 6 shows something of the effect of weather and other conditions on the rate of drying of green crops between the time of cutting and ensiling. Because of the better drying weather and lighter stand at the July date, the rate of drying was several times as fast then as under the fair but humid conditions and with the heavy crop found on June 8, 1937. Clearly, some attention to the weather is needed in timing the silo-filling operation.

TABLE 6.—Rapidly of Drying under Different Conditions

Crop	Description of sample	Per cent of dry matter
Mixed stand mostly alfalfa and clover, ensiled June 8, 1937. Very heavy stand. Generally wet season but bright day. Mower started at 8:30. Two loads A. M., 10 others, P. M.	Field (standing) .....	18.0
	Average (at silo) .....	22.7
Second-cutting alfalfa (same field as above) July 21, 1937. Much lighter stand than first cutting. Bright, hot sun, good drying day	Field (standing) .....	25.0
	First load, 11 A. M. ....	31.0
	Second load, 1 P. M. ....	34.0
	Average of three loads, later	44.0

Possibly the material of this section may best be summarized by reference to a diagram of a silo (Fig. 2). The material in the lower half of the silo, A, is probably under pressure ranging from 4 to 8 pounds per square inch, more than this in deeper-than-average silos. If material of less than 25 per cent dry-matter content is ensiled in this portion of the silo, there will probably be a loss of juice, the amount of which is determined by the two factors, dry-matter content of the crop and pressure from the weight of material above.

At 8 pounds' pressure and 18 per cent dry matter, the loss of juice in our experiment was 30 per cent. The dry-matter content of this juice was 6.5 per cent. This made 1.95 per cent loss of dry matter, based on the total weight, or 10.8 per cent of the original dry matter in the crop. If molasses had been added to this material a large part of that would also have been lost in the juice that ran away. In the upper portion of the silo, marked B, the pressure per square inch will vary from about 4 pounds near the center down to nothing at the surface. If material above 40 per cent in dry matter is ensiled in the upper part of this region, its weight is not usually sufficient to compact the mass properly. Excessive fermentation and spoilage result.

Here then are two sets of opposite extremes, both resulting in loss; both may be operating in the same silo at the same time. What practical advice can be given to the farmer in the absence of exact information about the dry-matter content of his crop to enable him to pursue a safe intermediate course?

Relatively dry material, even up to 45 per cent or more dry matter, may be safely ensiled in the lower part of a silo, provided there is wetter and heavier material above to compact it.

On the other hand, material of less than 25 per cent dry matter, which would leak badly in the bottom of the silo, may be ensiled without loss in the upper part, where the pressure is much less. If the lower part is filled with relatively dry material, any surplus juice coming from the material above will be absorbed. If wetter material is ensiled near the top of the silo, it will help to compact and seal the silo, thereby preserving the drier material beneath. The natural tendency to cut the entire crop at once should, therefore, be carefully avoided, for such a procedure results in placing the wet material at the bottom and the dry material at the top of the silo, just the opposite of the condition which would be most desirable. Rather, the crop should be cut in installments, depending on the progress of the filling, and by all means, the last material ensiled should be of low dry-matter content.

Immature hay crops, such as alfalfa and the clovers cut before full bloom, especially if the crop is heavy and the weather wet, should, we feel, be wilted for several hours, one-half day, or more before ensiling. Such crops should not be ensiled when wet with rain or dew. These recommendations apply with especial force to that part of the crop which will be placed in the lower portion of the silo. On the other hand, over-mature crops or light stands, especially if cut in good drying weather, should be ensiled as soon after cutting as possible.

A certain amount of extra water in the form of rain, dew, or artificially added water would often be desirable, especially near the top of the silo, when handling such crops under conditions which are inclined to make them dry quickly.

Most hay crops, except the extremes noted above, if cut at the proper stage for good haymaking and cut into the silo within 2 or 3 hours after mowing, will fall within the range of dry-matter content where losses will be avoided and good silage may be expected.

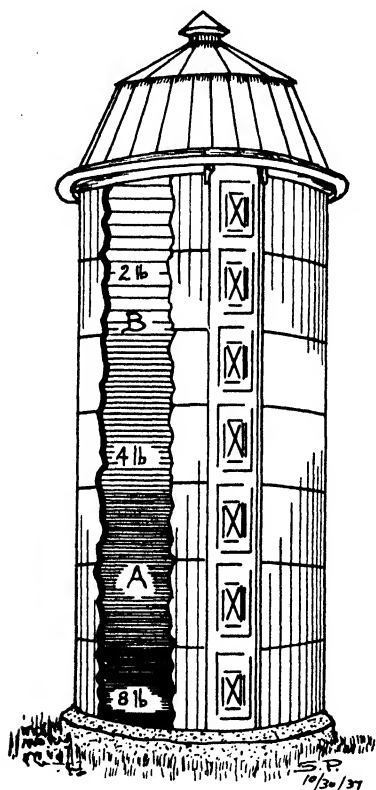


Fig. 2.—Drawing showing section of a silo shaded to represent approximately the pressure (in pounds per square inch) on the material at different levels

Figure 3 shows a satisfactory, convenient means of applying either diluted molasses or acid solution to the crop at the time of ensiling which has been used successfully at this institution for three seasons. It consists of a direct-connected motor-driven rotary displacement pump of bronze construction which is practically unaffected by acids. The pump has a rated capacity of 5 gallons per minute and has  $\frac{1}{2}$ -inch inlet and outlet connections. The cost of pump and motor was about \$30. As used here, it is connected directly with a steel drum (with one head removed) which serves as a reservoir. A water meter is shown connected between the pump outlet and the hose. This was very helpful in obtaining accurate experimental data but would not be essential to farm operation. The liquid is conveyed by means of a hose directly to the surface of the crop in the silo.

Molasses itself or molasses diluted somewhat to improve its flow is sometimes run onto the crop just as it enters the chopper or is introduced into the blower. The molasses may be allowed to flow from an elevated tank, or it may be delivered under pressure from a drum on the ground by pumping air into the drum.

Because of the corrosive effect of acid solutions on machinery, metal pipes, belts, clothing, and the like and their unpleasant and irritating effect on the eyes and skin, such solutions should not be introduced into the cutter or blower but should be applied directly to the surface of the silage by means of a suitable pump and hose, such as the one shown in Figure 3. Such an outfit is also convenient for adding extra water at the top of a silo or elsewhere to material which is thought to be overdry.

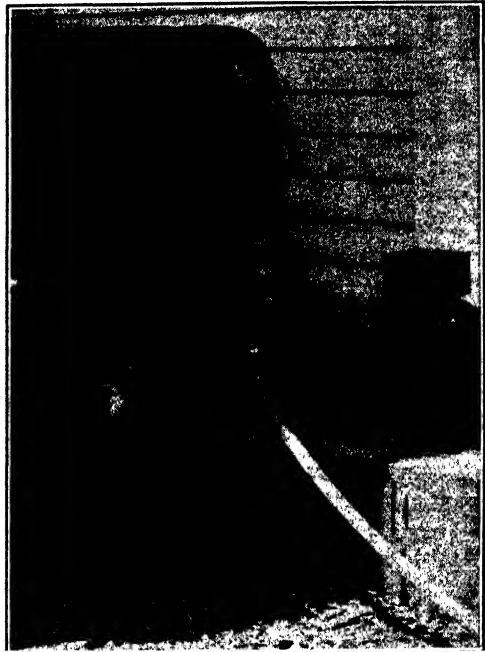


Fig. 3.—Motor-driven pump used for applying diluted molasses or acid solutions to crops as ensiled. The liquids are conveyed through the hose to the surface of the silage.

### CHOPPING HAY CROPS

The cutter should be set for relatively fine chopping. Regarding machinery which is suitable for chopping green hay for the silo, it may be said that some difficulty was encountered at first in using fillers designed for corn for the chopping of green hay; and some trouble may still be experienced with old machines. Most of the manufacturers, however, have made the slight changes in design which were necessary to adapt their newer machines for both purposes.

The question also frequently arises as to the type of silo required for keeping legume silage. To this, the answer may be given that any good silo suitable for storing corn silage satisfactorily will likewise be suitable for legume silage. The pressure developed may be somewhat greater with the legume silage, but most modern cylindrical silos have abundant strength to withstand the additional pressure.

### SEALING OR CAPPING THE SILO

Unless feeding is started within a day or two after filling the silo, there will develop a layer at the surface of the silage exhibiting the successive stages of fermentation and decay. If opening of the silo is considerably delayed, the surface of this spoiled portion will usually dry out, and the decay will extend to greater depths. The degree and extent of the spoilage, however, are not greatly different from those occurring in corn.

Many systems of sealing or capping the silo to prevent or diminish this waste, which in some cases may amount to several tons, have been proposed. One of the best practical procedures is as follows. On the day following the filling, the surface of the silage is leveled and thoroughly compacted; water is added if the material seems dry. The surface of the silage is then covered with lightweight tarred roofing. The joints are lapped about 2 or 3 inches. Enough of the ensiled material or other weight is added on top of the roofing to hold it in place. The joints in the roofing will usually soon be sealed by heat from the fermenting silage. The roofing then makes an effective moisture seal and prevents much of the spoilage which would otherwise occur. On several occasions the writers have substituted a less expensive cover of strong wrapping paper treated with lubricating oil for the roofing, with apparently very good results. If a less valuable green material, such as weeds, preferably of high moisture content, is available, a load or more of this substance at the top of the silo will supply the material which it seems necessary to lose by fermentation and decay, and the more valuable material will be left intact.

### SUMMARY

It has been amply demonstrated that a wide variety of plants, including the legumes and grasses commonly grown for hay, may be successfully stored in the form of silage. When properly made, hay silage preserves certain highly valuable properties of the green plants that are largely destroyed in the process of haymaking. The various proposed treatments have been discussed and evaluated. Evidence is presented that proper control of dry-matter content is probably the most important consideration in silage making. Means are suggested of securing practical control of this factor in the absence of exact information regarding it. There seems little doubt that the practice of making silage from hay crops will grow increasingly in favor as a supplement to and partial substitute for haymaking.

# COMPARATIVE RATES OF WATER LOSS FROM SOIL, TURF, AND WATER SURFACES

F. A. WELTON AND J. D. WILSON

Recent experiments conducted by the authors to determine the possibility of using an evaporation index as a criterion for the timing and amount of applications of water to turf grasses<sup>1</sup> have served to emphasize the need of further knowledge concerning the comparative rates of water loss from different surface types. The purpose of this experiment was to obtain such information as it pertains to a free water surface, bare soil, the same soil types covered with growing grass, and to the atmometer.

## MATERIAL AND METHODS

A series of pans, of such size (13.25 inches in diameter and 10 inches deep) that they and their contents could be easily and accurately weighed, were filled with the soils and soil mixtures described in Table 1. To provide subirrigation a ½-inch layer of coarse sand was first placed in the bottom of the pans; then bottomless bottles were set on this with the necks extending slightly above the rims of the pans. Soil was then added to each pan in such quantity that the combined weight of pan, bottle, sand, and soil was uniform for all pans in a particular soil group.

The pans in which grass was to be grown were seeded in May, 1936, with Kentucky bluegrass (5 pounds per 1000 square feet) or with Chewing's fescue (10 pounds per 1000 square feet), in sufficient number for use in the experiment. These seeded pans were then placed under a shade and watered as seemed fit until the grass was well established. At this time all the pans were placed in trenches of such depth that the pan rims were approximately level with the surrounding turf. The whole series was located within 100 feet of a standard Weather Bureau evaporation pan and a set of black and white atmometers.

The collection of weight records was then started in order to determine the relative rates of water loss from the different soil and turf groups under investigation. This was done by placing the pans on a solution balance, noting their actual weight, and restoring the original weight by the addition of water through the bottle neck. The weighings were made at irregular intervals; the time between any two was determined by the rate of water loss and the amount added by rains. Rains in excess of about 0.5 inch caused an excess of soil moisture, and for this reason the records on water loss were not continuous. If the soil moisture did not exceed field capacity, it was allowed to evaporate in the usual manner. If, however, the pans were flooded or free water was present in the sand layer at the bottom of the pans, the excess was siphoned off through the bottle neck as soon as possible. In the fall, all of the pans were removed to a greenhouse; there the collection of data was continued from December to April. The grass, except as noted, was clipped to simulate lawn conditions.

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<sup>1</sup>Wilson, J. D. and F. A. Welton. 1935. The use of an evaporation index in watering lawns. Ohio Agr. Exp. Sta. Bimonthly Bulletin 20: 112-119.

## RESULTS

The different soils and soil mixtures, the periods through which records were taken, and the water losses from the various pans of bare soil and turfs were as shown in Table 1. The losses from bare soil were expressed (upper section) as grams per square foot and represent the daily average of three pans for the period indicated in the column headings of the table. The effect of a covering of growing grass is expressed (middle section) as an increase (+) or a decrease (—), depending upon whether the loss of water was more or less than that from the corresponding lot of bare soil. In the last column, the weight (grams per square foot) of oven-dried grass produced during March and April is indicated.

An analysis of the data in Table 1 indicates that loss of water from the free water surface was greater than that from the Wooster silt loam or any modification of it. The muck, which lost water most rapidly of any of the soil media while outdoors, lost only about three-fifths as much as did the free water surface. The incorporation of peat to a depth of  $\frac{1}{2}$  inch in the surface of the Wooster silt loam inhibited the loss of water from the bare soil throughout the test. The loss was slightly less than three-fourths that of the bare soil during the summer period. In the greenhouse also the loss was less, but the difference was not marked. The addition of 3 parts of well-rotted manure to 1 part of soil caused a similar reduction in the loss from Wooster silt loam alone. When sand was added in the same proportions, the sand-loam mixture lost slightly more water than loam alone while the pans were outside. In the greenhouse the difference was somewhat greater. The data on muck are interesting, because the rate of loss outside during the summer was considerably greater than from Wooster silt loam; whereas in the greenhouse the losses were practically equal. The black color of the muck was apparently responsible for considerable heat absorption from sunlight during the summer months; this speeded up the rate of water loss until it was above that from any of the other soil mixtures.

A covering of growing grass increased the average rate of water loss over that from bare soil except on the loam-sand mixture. The greatest increase due to the grass covering occurred with the loam-manure mixture, and the average rate of loss during the summer period was nearly as great as from a free water surface. In fact, it was actually greater during July, August, and September. The grass was much more luxuriant and grew more rapidly on this medium than on any of the others used. That a turf, such as this, may in some instances lose water as fast by evaporation and transpiration as does a free water surface by evaporation is significant in connection with the use of an evaporation index as a criterion in lawn irrigation practice, since many of the tests made by the authors (1) have involved the assumption that an inch of water should be added to the soil for every inch that evaporates from a free water surface. Part of the water added by sprinkling the lawn or fairways is always lost by evaporation before it reaches or penetrates the soil; some is usually lost by runoff; and still another portion may be lost by drainage into the subsoil. Therefore, an inch-for-inch replacement should not tend to accumulate an excess of water in most soils when due allowance is made for what falls as rain. The Livingston standardized atmometer has been used in these watering experiments instead of a free water surface, such as an open pan, because of the greater convenience of operation. The conversion factor of 270 which is used in these tests for reducing cubic centimeters of water loss from



the black atmometer to inches from the open pan proved to be very accurate in this case, since the average daily loss for the 42 summer days involved was 0.191 inch in terms of the atmometer conversion; whereas the actual loss was 0.189 inch from a near-by evaporation pan.

The high rate of water loss from the loam-sand mixture was not materially increased by a covering of grass; in fact, it was actually decreased when the whole period of the test was considered. This was probably due in part to the sparse covering and rather poor growth. Grass grew well on the muck soil, but here again it did not greatly or even consistently increase the rate of water loss outdoors where evaporation from the bare soil was high. Apparently the grass covering decreased evaporation from the soil by shading nearly as much as it increased the total water loss by transpiration. The effect, however, was positive in terms of increased water loss in the greenhouse instead of negative, as with sand.

Grass cut 3 inches high lost about 35 per cent more water than did that cut 1 inch high. The loss of water was neither markedly nor consistently affected by the two kinds of turf, Kentucky bluegrass and Chewing's fescue. The Kentucky bluegrass grew best on the loam-manure mixture and poorest on the loam-sand mixture.

### SUMMARY

The results of this experiment seem to indicate the following:

1. The rate of water loss from a free water surface was greater than that from bare soil.
2. The rate of water loss from the Wooster silt loam was diminished by a mulch of peat and by the incorporation of manure but increased by the addition of sand. It was less than the rate of loss from muck.
3. The rate of water loss from bare soil was less than that from the same types of soil covered with growing grass, except in the case of the sand-loam mixture.
4. The rate of water loss was greater from grass cut 3 inches high than from grass cut 1 inch high.
5. The rate of water loss from the two species of grass included did not differ greatly.

# **LIVABILITY OF LAYERS MAY BE PREDETERMINED BY MANAGEMENT OF THE CHICKS**

**D. C. KENNARD AND V. D. CHAMBERLIN**

The most critical question facing the poultry industry today is that of the huge losses of adult birds from disease and internal parasites. According to a recent authoritative estimate, during 1936 these losses amounted to \$6,483,774 in Ohio alone. In 10 leading poultry states they totaled \$43,500,000. Since no state has a monopoly on this side of the poultry business, what would the loss be for the country as a whole? These losses represent dead birds only. In addition, there are the losses from an equal or greater number of cull birds. Culls are inferior or unfit birds, many of which are removed in anticipation of death; a small proportion of such birds is salvaged as market poultry (inferior grades for the most part).

A survey of poultry farm demonstration records, secured under state supervision, from a number of leading poultry states reveals that the average first-year flock reduction of pullet layers is from 40 to 60 per cent; that 15 to 25 per cent is due to mortality; and that the balance is due to culls.

## **A SPECIFIC EXAMPLE**

The history and experiences of the Ohio Station's poultry plant during the past 15 years may be cited as a specific instance of what has been taking place in varying degrees throughout the country at large. The average first-year mortality (no culls removed) of pullet layers from 1921 to 1924 was 13.2 per cent; from 1925 to 1928, 38.4 per cent; and from 1929 to 1937, 50 to 60 per cent. Although there was a marked rise in mortality from 1925 to 1928, it was after 1928 that the losses mounted to a half or more of the Station's flocks. Coincidentally, it was in 1928 that fowl paralysis and allied complications made their first appearance at the Station; they have since been the primary causes of losses.

There are a number of possible lines of attack, such as preventive management (including sanitation), pathology, parasitology, breeding, nutrition, treatment, and remedies. Of these, management, pathology, parasitology, and breeding (especially for vigor, longevity, and disease-resistant strains) would seem to offer the most promising possibilities at this time. Undoubtedly, preventive management is the best immediate procedure for a poultryman now facing a disease situation. Despite its uncertainties, preventive management offers the best assurance of effective results.

Breeding has remote possibilities, but as Jull states in *Poultry Science* (1), "The study of the inheritance of resistance to disease is beset with many difficulties, a few of which are mentioned here with a view toward arriving at a more complete understanding of all of the problems involved". Some of the difficulties he points out are: "There is frequently considerable difficulty in determining the specific cause of death; it is sometimes difficult to find strains or families having any resistance to a specific disease; one of the greatest diffi-

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1. May, 1936.

culties, as Lambert and Knox have observed, is the establishment of definite criteria of resistance; variation in bacterial virulence is a vital problem that sometimes occurs; the difficulty of controlling the pathogenic organism involved in any study represents a problem of major importance; the difficulty in distinguishing natural from acquired immunity interferes with the selective process; since resistance to infections is usually specific, there must be selection for each of numerous diseases, thus limiting greatly what can be accomplished in a general way, as Cole (1930-1932) has pointed out; Cole has also pointed out that selection for resistance to disease adds to the characters already being selected for, thus complicating the breeding program."

The problem of raising livable pullets has been the chief subject of investigation at the Station's poultry plant during the past 10 years. The problem was attacked from the point of management only, because of the limited funds, equipment, and personnel available for poultry investigations. Tests of various management procedures with chicks and growing pullets were begun in 1928. The primary object of the tests was to demonstrate to what extent the losses of pullet layers might be affected by management.

These tests included the raising of chicks and pullets on fresh range, confined to wire sun porches with and without fly screen, indoors, and in batteries. All failed to reduce the losses of pullet layers materially. After these management procedures failed to reduce the mortality of pullet layers, the breeding stock was suspected of being responsible. Therefore, 5-month-old, ready-to-lay pullets were secured for test purposes from two poultry farms in widely different sections of the State. Some of these pullets were housed in pens adjoining Station-raised pullets (separated by wire partitions). In other pens the imported pullets were mixed half and half with the Station's pullets. The average production from the imported pullets and the Station's for 50 weeks was 170 versus 128 eggs, and the mortality was 26 versus 66 per cent, respectively.

These results seemed to indicate that the Station's breeding stock was responsible for the inferiority of the Station's pullets. In pursuance of this idea, the following year hatching eggs were secured from one of the sources of the imported pullets which had rendered such a good account of themselves at the Station's poultry plant. Contrary to expectations, the pullets hatched from imported eggs and raised in the proximity of the Station's poultry plant were a failure both as to livability and egg production. The experiment with imported hatching eggs was tried again a second year with another source of hatching eggs from breeding flocks supposedly free of fowl paralysis and the other principal causes of mortality of the Station's flocks.

Both years, the use of imported hatching eggs from two widely different sources increased rather than decreased the losses of pullet layers. It appears that the Station's pullets may have had some inherent disease resistance not possessed by the pullets from breeding flocks supposedly free of the diseases in question.

From the tests with imported ready-to-lay pullets and the tests with pullets hatched from imported eggs and raised at the Station, it became clear that the Station's breeding stock was not primarily responsible, that the problem was not one of breeding, but one of management. It was the management of the day-old chick from the time it was taken from the incubator until it became a ready-to-lay pullet that had largely predetermined the livability and egg production of these pullet layers.

With the elimination of breeding as a major factor in the mortality problem, the line of attack became simplified to that of preventive management by isolation of chicks and growing pullets from older disease-carrying birds, sanitation, and good poultry husbandry. The problem had been further simplified, for it appeared that the primary object could be realized by concentrating the preventive management precautions upon the chicks and growing pullets; that if the chicks and growing pullets could be adequately safeguarded against diseases and internal parasites of older birds, more than half the battle was won. The correctness of this interpretation of the first 7 years' work seems to have been substantiated by the tests which followed, the results of which are given in Table 1.

### DESCRIPTION OF TESTS

Tests 1, 2, 3, and 4 were conducted with imported ready-to-lay White Leghorn pullets in comparison with Station-raised Leghorn pullets of practically the same age. There appeared to be no particular disease situation among the older birds either place the pullets were raised. The sanitary conditions at one of the places were far below those maintained at the Station's poultry plant.

Test 1 represents 50 imported pullets from one source (preventive management) in a separate pen (separated by wire netting partition) but adjoining a pen of an equal number of Station-raised pullets (nonpreventive management). Test 3 was another source of 50 imported pullets (preventive management) adjoining another group of 50 Station-raised pullets (nonpreventive management); whereas Test 2 was a mixture of 25 imported pullets (as in preventive management Test 1) and 25 Station-raised pullets (as in nonpreventive management Test 1). Test 4 was also a mixture of 25 of the other source of imported pullets (as in Test 3) and 25 Station-raised pullets (as in Test 3).

The second series of tests with the Station's stock was begun in 1935 when the Station's day-old chicks were taken directly from the incubator and shipped about 150 miles to the Clermont and Miami County Experiment Farms where the chicks were brooded and the pullets reared in the usual way. When the pullets were ready to lay, they were returned to the Station for test purposes. There were older birds on each farm, but they appeared not to be affected by disease or internal parasites in either instance. The same procedure was repeated at these farms the following year.

After the first year's success of pullet layers from the Station's chicks raised on the experiment farms, it seemed desirable to see if similar results might be secured with the Station's chicks nearer home and more in line with what would be a practicable procedure for poultrymen to undertake. Accordingly, 1500 chicks were brooded and raised on a 7-acre range adjoining the Station's poultry plant. This was a bluegrass range with a scattering of shade trees. It had been used in the preceding years for raising pullets. However, there were no chickens on this range from October to March (6 months) before the test. The range was enclosed with poultry fencing. Further precautions were taken to protect the chicks and growing pullets from exposure to the ills of older birds at the poultry plant by the use of separate equipment and utensils; the feed was secured ready mixed from a feed company in Wooster and delivered directly to a colony house feed storage on the range. In other words, a procedure was attempted with precautions that would be considered practicable by most poultry raisers. The relative effectiveness of this modified procedure and the results of the other tests are given in Table 1.

**TABLE 1.—Mortality and Egg Production of Pullets as Affected by Preventive and Nonpreventive Management of Chicks and Growing Pullets**

Date and test number	Duration of tests	Mortality		Eggs per bird			
		Preventive management	Non-preventive management	Hen days*		Original number†	
				Preventive management	Non-preventive management	Preventive management	Non-preventive management
1930-1931	<i>Weeks</i>	<i>Pct.</i>	<i>Pct.</i>				
1.....	50	18.0	68	154	120	139	71
2.....	50	20.0	56	138	102	131	83
3.....	50	40.0§	76	186	160	154	102
4.....	50	28.0	64	202	130	178	89
Averages.....		26.0	66	170	128	150	86
Per cent‡.....		60.6	.....	24.7	.....	42.7	.....
1935-1936							
5.....	50	22.0	62	196	182	177	125
6.....	50	24.0	62	207	164	187	114
Averages.....		23.0	62	201	173	182	119
Per cent‡.....		63.0	.....	13.9	.....	34.6	.....
1936-1937							
7.....	48	24.0	70	180	132	150	60
8.....	48	42.0	47	171	132	142	106
9.....	48	44.0	53	182	139	143	98
10.....	48	29.0	38	178	146	142	124
11.....	48	33.0	38	166	145	137	116
Averages.....		34.0	49	175	139	143	101
Per cent‡.....		30.6	.....	20.6	.....	29.4	.....
Grand average.....		28.0	59	182	147	158	102
Grand average per cent‡.....		48.9	.....	20.8	.....	35.3	.....

\*Total number of eggs divided by average number of living birds.

†Total number of eggs divided by number of birds at the beginning of the test.

‡Per cent less mortality and per cent more eggs from preventive management than non-preventive management.

§The higher rate of mortality of this group was due to colds contracted during shipment.

**EGG PRODUCTION PER BIRD, O. N. AND H. D.**

The egg production in Table 1 is expressed in two different ways. To aid in the interpretation of the results an explanation of the two methods is given here.

The two methods used in expressing egg production per bird are: (a) Eggs per bird O. N. (original number) and (b) eggs per bird H. D. Eggs per bird O. N. is calculated on the basis of the number of ready-to-lay pullets or layers at the beginning of the year or test when the birds are housed. The total number of eggs laid by the flock is divided by the number of birds at the beginning. Eggs per bird H. D. (hen days) is calculated on the basis of the average number of living birds during the period for which the calculation is made; the total number of eggs laid by the flock is divided by the average number of living birds. When eggs per bird are not designated otherwise it is to be assumed that they have been calculated on the basis of H. D.

To use a specific example, let us take 10 ready-to-lay pullets that during the year to follow lay a total of 1440 eggs or 144 eggs per bird O. N. (original number). That is simple and easy to calculate. When a poultryman starts with a flock of ready-to-lay pullets his chief concern is how many eggs per bird O. N. he will secure. It is upon this basis that his investment in the pullets, housing, and equipment is made. Now let us assume that two pullets died and two were removed as culls during the year; this leaves 6 hens at the end of the year (a conservative estimate). The 144 eggs per bird O. N. takes these removals into account. In other words, eggs per bird O. N. accurately reflects the losses from mortality and culls. It is a factual figure. That is why it is only 144, and perhaps that is why egg production is seldom expressed as eggs per bird O. N.; whereas it is almost invariably expressed as eggs per bird H. D.

Now let us calculate eggs per bird H. D. for the 10 pullets on the basis of 40 per cent loss of pullets from mortality and culls. First, what was the average number of living birds during the year? How many hen days were lost by the four dead and cull birds? Had all lived there would have been 3650 hen days (365 times 10). Let us suppose that one pullet died at the end of 30 days; another was culled (removed before she would have died, perhaps) on the ninety-fifth day; another died at the end of 265 days; and the fourth was culled at the end of 340 days. The total hen days these four dead and cull birds were in the flock was 730 instead of 1460 days, as it would have been had they remained in the flock the whole year. Since 365 days represents one bird for a year, the loss of 730 hen days amounts to an average flock reduction of two birds. Hence, the average number of living birds for the year was eight, and the egg production per bird H. D. was 180 (1440 divided by 8). The greater the losses from dead and cull birds become, the lower eggs per bird O. N. becomes; whereas eggs per bird H. D. tends to become greater, for it is well known that it is the inferior birds that tend to die or become culls; whereas the better birds tend to live and lay through the year.

When it comes to judging the performance of a flock as a whole from the point of breeding, management, and economics, eggs per bird H. D. becomes a misleading expression whenever the flock reduction from mortality and culls exceeds 10 per cent. In these days of mounting losses from mortality and culls there may be a temptation to prefer the higher figure of eggs per bird H. D. over the lower, more factual figure of eggs per bird O. N.

## DISCUSSION OF RESULTS

In Tests 1 to 4 the average mortality of the imported pullets was less than half (60.6 per cent less) that of the Station-raised pullets despite the relatively high mortality (40 per cent) of the imported pullets in Test 3, 16 per cent of which was due to colds contracted during shipment. The egg production averaged 24.7 per cent greater on the basis of eggs per bird H. D. and 42.7 per cent greater on the basis of eggs per bird O. N. or the total number of eggs laid by the imported flocks as a whole. Besides largely solving the problem of livability and increased egg production, the imported pullets demonstrated the very important fact that after they were ready to lay they were comparatively non-susceptible to certain of the most baffling diseases, such as fowl paralysis, leucosis (big liver disease), and a number of cholera-like diseases. Not only did the imported pullets fail to contract these diseases from Station-raised

pullets when they were in adjoining pens (separated by wire netting partitions), but also when they were in a half-and-half mixture of imported pullets and Station-raised pullets (Tests 2 and 4). Despite their being together a year, the imported pullets in both tests maintained their marked differential over the Station-raised pullets in respect to livability and egg production. This resistance of ready-to-lay pullets not previously exposed, to the diseases in question (and others, including the ill effects of colds and chicken pox) has been observed in many other instances at the Station. Assuming that this resistance can be relied upon when the previous requirements are fulfilled, it would be fortunate indeed if we could largely solve the problems of disease and internal parasites by concentrating our efforts upon the preventive management of chicks and growing pullets.

It was not until Tests 5 and 6 were conducted with ready-to-lay pullets from the Station's chicks raised entirely away from the Station that we could be certain why the imported ready-to-lay pullets had rendered such a favorable account of themselves 4 years before. Tests 4 and 5 gave conclusive proof that it was the management of the chicks from the time they were taken from the incubator until the pullets became ready to lay that was largely responsible for the successful behavior and performance of the imported pullets, as well as the Station-raised pullets (preventive management) in Tests 5 and 6.

Tests 5 and 6 were repeated at the same experiment farms the following year, and are designated as Test 7. Although the tests were repeated, the favorable results on one farm were not repeated because of an outbreak of coccidiosis when the pullets were 10 to 12 weeks of age. Since coccidiosis is preventable, the pullets from this farm are designated as under nonpreventive management in Test 7, and the pullets from the other farm, where the first year's favorable results were repeated, are designated as having preventive management. Here is a concrete example of how the behavior and performance of pullet layers may be affected by their previous management as chicks and growing pullets. The percentage of mortality under preventive management was 24, under nonpreventive management, 70. The eggs per bird H. D. totaled 180 versus 132; eggs per bird O. N., 150 versus 60. These were pullets from the same breeders hatched in the same incubator at the same time and shipped as day-old chicks the same day. This offers food for thought both for hatcherymen and poultry raisers.

Tests 8, 9, 10, and 11 represent the past year's results of preventive management at the Station's poultry plant. Test 8, preventive management, represents the pullets raised on the adjacent isolated range previously described. In this instance there was not a marked difference in mortality (42 versus 47 per cent) in favor of preventive management, but there was in egg production. Eggs per bird H. D. averaged 171 versus 132; eggs per bird O. N., 142 versus 106.

In Test 9 the preventive management was confinement of the pullets to a wire sun porch located on a range used by other pullets of the same age and about 150 feet from hens on a yarded range. It proved as effective in this instance as the isolated range.

Tests 10 and 11 correspond to 8 and 9, respectively, except that these groups (24 each) of pullets were in individual laying batteries instead of floor pens. The differences in favor of the preventive management groups in livability and egg production were practically the same for the pullets in batteries

as for similar pullets in floor pens. Obviously the first year's attempt at preventive management on the isolated range adjoining the Station's poultry plant did not prove as effective as raising the chicks and pullets entirely away from the poultry plant. Perhaps this modified procedure fails to meet the requirements fully. However, the test will need to be repeated 3 years or more before the merits of the procedure can be judged.

Taken as a whole, the results of the 11 tests are consistent and promising. Mortality was halved and egg production was increased 20.8 per cent H. D. and 35.3 per cent O. N. What other procedure for increasing livability and egg production of pullet layers at this time offers the immediate assurance of results comparable to these?

It must not be assumed from this that preventive management offers more than an immediate partial relief from the losses of pullet layers where an acute disease and parasite (internal) situation exists. It is but a partial control until more intelligent scientific preventive management procedures become available. What is needed to bring this about is more definite and comprehensive research information dealing with the causes, means of transmission, prevention, and control of diseases, including the role of "carriers" in the dissemination of disease and internal parasites. With such information, effective prevention and control measures could be undertaken intelligently.

## OHIO AGRICULTURAL INCOME

F. L. MORISON

The relative importance of the various sources of income from Ohio's diversified farming industry is shown in Table 1. During the 8-year period, 1929 to 1936, sales of livestock and livestock products made up 67.5 per cent of the gross cash receipts. The sale of dairy products alone accounted for 21.6 per cent. If the sale of dairy cattle and veal calves were added to the income from dairy products, the importance of the dairy industry in the State would be even more striking. Hogs ranked second as a source of income during this period. During an earlier period, 1924 to 1928, hogs were first, bringing in 21.2 per cent of the total income; whereas dairy products were second.

The total income from the sale of crops accounted for 30.7 per cent of the gross cash receipts during the 8-year period. Wheat, from the standpoint of sales, was the most important single crop, producing 8 per cent of the total income. Only half that much was derived from the sale of corn outside the State or to non-farmers within the State. These figures, representing income from sale of the commodity specified, minimize the importance of the corn crop. Thus, in 1936 only 19 million dollars' worth of corn was sold, although the total value of the Ohio corn crop that year was \$122,000,000.

Included in the item "other crops" are the other small grains, rye, barley, and buckwheat; soybeans, which are becoming of more importance as a cash crop; alfalfa, clover, and timothy seed; sugar beets; nursery and greenhouse

products; maple products; and forest products. Of these miscellaneous items, greenhouse products were most important, with 2.3 per cent of the total income; nursery products were next, with 1.3 per cent.

Table 1 also shows the trend in income from each of the various products and for the industry as a whole. The total gross income in 1936 was nearly double that received in the year 1932. For 1937, the income for Ohio's agricultural industry is estimated at \$343,000,000, an increase of 10 per cent over 1936.

**TABLE 1.—Gross Cash Income of Ohio's Agricultural Industry,  
by Sources, 1929-1936**

	Gross cash income, in millions of dollars								Per cent of total, 8-year average
	1929	1930	1931	1932	1933	1934	1935	1936	
Corn.....	12.3	10.1	7.5	6.8	6.5	8.6	9.2	19.0	4.0
Wheat.....	24.2	14.0	13.8	11.2	20.9	22.9	27.0	28.2	8.0
Oats.....	6.5	4.8	3.3	2.3	1.5	1.5	2.2	3.5	1.3
Hay.....	7.7	5.7	3.9	2.9	2.1	3.3	3.9	3.5	1.6
Potatoes.....	8.2	6.7	4.7	3.4	5.5	5.3	5.0	8.7	2.4
Truck crops.....	5.7	4.2	9.7	4.5	6.5	7.9	8.0	6.5	2.6
Fruit.....	5.6	4.6	8.0	5.5	5.7	6.4	8.8	5.0	2.4
Tobacco.....	7.0	6.2	5.9	3.5	2.4	2.2	2.8	2.5	1.6
Other crops.....	21.6	21.3	16.4	10.8	13.5	15.2	17.7	20.9	6.8
Total crops.....	98.8	77.6	73.2	50.9	64.6	73.3	84.6	97.8	30.7
Hogs.....	62.9	61.5	40.5	26.0	32.6	34.5	51.0	61.2	18.3
Cattle and calves.....	38.1	32.7	21.7	18.4	19.2	20.1	32.7	33.3	10.7
Dairy products.....	79.2	66.6	51.2	35.7	37.0	47.7	54.5	64.5	21.6
Sheep and wool.....	12.7	9.1	7.1	5.5	7.9	9.9	11.0	12.4	3.7
Poultry and eggs.....	52.7	40.7	32.1	23.0	21.2	26.4	35.4	34.6	13.2
Total livestock....	245.6	210.6	152.6	108.6	117.9	138.6	184.6	206.0	67.5
Government payments.....	.....	.....	.....	.....	1.2	11.5	15.2	8.0	1.8
Total.....	344.4	288.2	225.8	159.5	183.7	223.4	284.4	311.8	100.0

# INDEX NUMBERS OF PRODUCTION, PRICES, AND INCOME

J. I. FALCONER

From July to October, 1937, the level of prices for Ohio farm products sold declined 11 per cent.

In November of 1937 the price of corn was one-half that of a year ago, and hog prices were \$1.00 per hundredweight lower. In general, crop prices had declined more than livestock prices.

Higher yields would in part make up for the lower prices received for crops. The total cash income from sales, however, was 5 per cent less in October of 1937 than in October of 1936.

From the income for the first 10 months of the year, it would now appear that the cash income of Ohio farmers for the year 1937 will exceed that of 1936 by about 10 per cent.

Trend of Ohio Prices and Wages, 1910-1914=100

	Wholesale prices, all commodities U. S.	Weekly earnings N. Y. State factory workers	Prices paid by farmers	Farm products prices U. S.	Ohio farm wages	Ohio farm real estate	Ohio farm products prices	Ohio cash income from sales
1913.....	102	.....	101	101	104	100	105	101
1914.....	99	100	100	101	102	102	105	108
1915.....	102	101	105	98	103	107	106	111
1916.....	125	114	124	118	113	113	121	121
1917.....	172	129	149	175	140	119	182	199
1918.....	192	160	176	202	175	131	203	240
1919.....	202	185	202	213	204	135	218	266
1920.....	225	222	201	211	236	159	212	226
1921.....	142	203	152	125	164	134	132	130
1922.....	141	197	149	132	145	124	127	130
1923.....	147	214	152	142	166	122	134	144
1924.....	143	218	152	143	165	118	133	146
1925.....	151	223	157	156	165	110	159	174
1926.....	146	229	155	145	170	105	155	177
1927.....	139	231	153	139	173	99	147	165
1928.....	141	232	155	149	169	96	154	156
1929.....	139	236	153	146	169	94	151	165
1930.....	126	226	145	126	154	90	128	137
1931.....	107	207	124	87	120	82	89	100
1932.....	95	178	107	65	92	70	63	73
1933.....	96	171	109	70	74	59	69	85
1934.....	110	182	123	90	77	63	85	98
1935.....	117	191	125	108	87	68	110	127
1936.....	118	199	124	114	100	74	118	147
1936								
July.....	118	198	123	115	105	.....	121	189
August.....	119	202	126	124	.....	.....	131	183
September.....	119	198	127	124	.....	.....	127	169
October.....	119	202	127	121	108	.....	124	164
November.....	120	201	127	120	.....	.....	123	158
December.....	123	211	128	126	.....	.....	127	160
1937								
January.....	125	209	130	131	104	.....	128	151
February.....	126	211	132	127	.....	.....	127	141
March.....	128	218	132	128	.....	77	129	157
April.....	128	219	134	130	118	.....	134	170
May.....	127	219	134	128	.....	.....	135	164
June.....	127	220	134	124	.....	.....	134	162
July.....	128	218	133	125	123	.....	138	191
August.....	128	220	132	123	.....	.....	135	171
September.....	128	215	130	118	.....	.....	129	164
October.....	125	214	128	112	127	.....	123	156



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## Ohio Agricultural Experiment Station

WOOSTER, OHIO, U. S. A.



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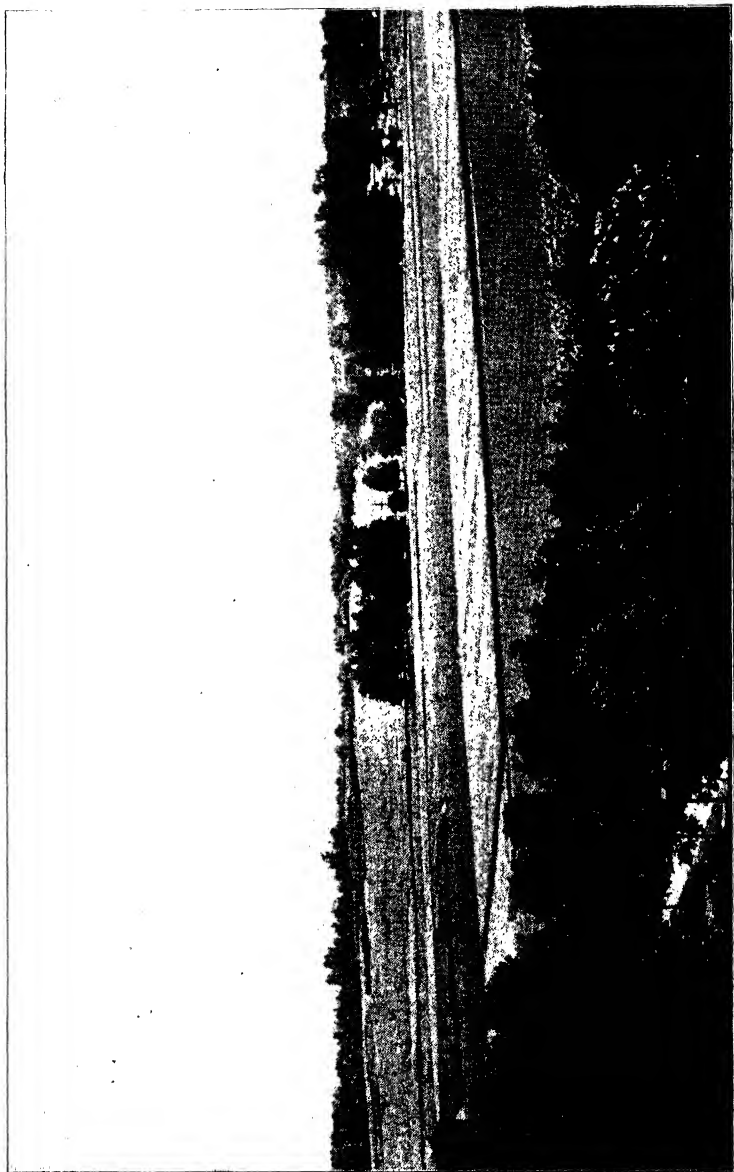
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*Edmund Secrest*  
Director



From the tower of the Administration Building, looking southeast, showing some of the experimental fields

# DATA AND NOTES ON CERTIFIED CORN HYBRIDS FOR OHIO<sup>1</sup>

G. H. STRINGFIELD<sup>2</sup>

The purpose of this paper is to present essential comparative data taken before 1937 and brief descriptive notes on the leading corn hybrids for Ohio. Because of the rapid change to better hybrids in the last few seasons, many of the comparisons are so far only preliminary. Only varieties regarded as standards against which to compare the hybrids are reported. The hybrids included are now being offered to Ohio farmers as "certified" hybrids for the 1938 planting. This list will be changed as necessary in future years to include the better hybrids located by similar tests of performance.

The data presented were taken from experiments in Hamilton, Clermont, Montgomery, Miami, Madison, Franklin, Meigs, Belmont, Paulding, Henry, Wayne, Mahoning, and Trumbull Counties. In general, each experiment included not less than 25 nor more than 100 entries, comprised of hybrids and varieties. Within a given experiment, time and method of planting, fertilizer application, and cultural treatment were all as nearly uniform over the entire planting as possible. The experimental fields were laid out as one might mark off a sheet of paper into five parallel strips across the sheet (ranges), then into five parallel strips up and down the sheet (blocks) at right angles to the ranges. The competing strains were then planted in plots two hills by ten hills with five-fold replication. Each strain appeared just once in each range and just once in each block. Aside from these two requirements, the planting order was random. Yields are given in bushels per acre of shelled grain at 15.5 per cent moisture. Lodging is reported as the percentage of total plants which were more than half down or which were broken below the ear.

The accompanying six tables are set up to permit making rapid comparisons of any hybrid or variety with competing strains. First, the strains are divided into an early and a late group with the midseason strains, Woodburn, Iowa 939, and Ohio W17, occurring in both groups. Each group is treated in three tables giving consideration to the three important items, acre yield, dryness of ears at harvest, and lodging, respectively. Each small square in the tables contains data comparing the strain listed above it at the top of the column with the strain listed at the left of the respective row. The small figure in the upper right corner of a square gives the number of experiments in which the two strains were compared. The upper of the other two figures gives the average performance of the strain listed above (yield, dryness, or lodging) and the lower figure gives the average performance of the strain to the left.

Suppose one wishes to compare Medina Pride with other strains. Following down the column headed by Medina Pride in Table 1, he will see in the second square that Medina Pride and Waugh were compared in 17 experiments.

<sup>1</sup>In cooperation with the Division of Cereal Crops and Diseases, Bureau of Plant Industry, United States Department of Agriculture.

<sup>2</sup>The writer is indebted to R. D. Lewis, Agronomy Extension, Ohio State University, and United States Bureau of Plant Industry, for helpful criticisms of the manuscript and for collaboration in preparing the map showing adaptation areas.

In these 17 experiments Medina Pride averaged 48.3 bushels per acre and Waugh averaged 53.9 bushels per acre. Other yield comparisons with Medina Pride may be made by following on down the column. Or, to investigate further the comparison between Medina Pride and Waugh, it may be noted in the corresponding square in Table 2 that Medina Pride averaged 71.0 per cent of dry matter in the ears at harvest; that Waugh averaged 71.4. Or it may be seen in the corresponding square in Table 3 that Medina Pride averaged 24.4 per cent of lodged plants and that Waugh averaged 29.0. Lodging data were taken in only seven of the comparisons.

TABLE 1.—Comparative Grain Yield Data for Earlier Hybrids and Varieties

In each square the small figure (upper right corner) shows the number of direct comparisons between the corresponding strains at the top and left of the table. The other two values give average yields; the upper yield value is that of the strain at the top of the table and the lower value is that of the strain at the left. **Example:** The respective yields of Medina Pride and Waugh in 17 comparative tests were 48.3 bushels for Medina Pride and 53.9 bushels for Waugh.

	Medina Pride	Waugh	Cook	K23	K24	Ia. 931	K35	Woos- ter Clar- age	Wood- burn	W17	Ia. 939
Medina Pride		53.9 <sup>17</sup> 48.3	70.7 <sup>9</sup> 58.8	87.0 <sup>8</sup> 67.4	81.6 <sup>4</sup> 65.0	81.9 <sup>8</sup> 63.5	118.4 <sup>1</sup> 78.8	50.1 <sup>37</sup> 46.0	55.1 <sup>29</sup> 47.6	87.1 <sup>6</sup> 66.8	86.8 <sup>7</sup> 61.2
Waugh	48.3 <sup>17</sup> 53.9		73.1 <sup>8</sup> 67.6	83.8 <sup>4</sup> 68.2	81.4 <sup>3</sup> 68.0	65.8 <sup>4</sup> 67.1	118.4 <sup>1</sup> 93.6	54.6 <sup>13</sup> 56.3	51.3 <sup>12</sup> 50.1	86.8 <sup>3</sup> 68.0	85.8 <sup>3</sup> 68.0
Cook	58.8 <sup>9</sup> 70.7	67.6 <sup>8</sup> 73.1		98.3 <sup>3</sup> 92.7	81.4 <sup>3</sup> 72.7	78.4 <sup>7</sup> 75.4	118.4 <sup>1</sup> 93.6	64.6 <sup>7</sup> 74.9	62.7 <sup>6</sup> 69.0	86.8 <sup>3</sup> 72.7	85.8 <sup>3</sup> 72.7
K23	67.4 <sup>8</sup> 87.0	68.2 <sup>4</sup> 83.8	92.7 <sup>3</sup> 98.3		81.1 <sup>4</sup> 83.1	85.1 <sup>5</sup> 86.9	89.6 <sup>2</sup> 79.0	82.0 <sup>3</sup> 98.3	51.3 <sup>5</sup> 61.5	87.3 <sup>4</sup> 83.1	87.3 <sup>4</sup> 83.1
K24	65.0 <sup>4</sup> 81.6	68.0 <sup>3</sup> 81.4	72.7 <sup>3</sup> 81.4	83.1 <sup>4</sup> 81.1		73.9 <sup>6</sup> 75.0	86.1 <sup>3</sup> 76.1	79.3 <sup>2</sup> 96.2	40.1 <sup>3</sup> 46.6	76.1 <sup>7</sup> 69.3	72.5 <sup>7</sup> 69.3
Ia. 931	63.5 <sup>8</sup> 81.9	67.1 <sup>4</sup> 65.8	75.4 <sup>7</sup> 78.4	86.9 <sup>5</sup> 85.1	75.0 <sup>6</sup> 73.9		86.1 <sup>3</sup> 76.9	74.1 <sup>6</sup> 79.7	63.6 <sup>4</sup> 71.2	82.8 <sup>7</sup> 75.7	79.8 <sup>7</sup> 75.7
K35	78.8 <sup>1</sup> 118.4	93.6 <sup>1</sup> 118.4	93.6 <sup>1</sup> 118.4	79.0 <sup>2</sup> 89.6	76.1 <sup>3</sup> 86.1	76.9 <sup>8</sup> 86.1		85.5 <sup>1</sup> 118.4	41.3 <sup>1</sup> 60.7	81.8 <sup>3</sup> 86.1	81.6 <sup>3</sup> 86.1
Wooster Clarage	46.0 <sup>37</sup> 50.1	56.3 <sup>13</sup> 54.6	74.9 <sup>7</sup> 64.6	98.3 <sup>3</sup> 82.0	96.2 <sup>2</sup> 79.3	79.7 <sup>6</sup> 74.1	118.4 <sup>1</sup> 85.5		50.8 <sup>19</sup> 47.1	99.1 <sup>2</sup> 79.3	96.5 <sup>4</sup> 68.7
Woodburn	47.6 <sup>29</sup> 55.1	50.1 <sup>12</sup> 51.3	69.0 <sup>6</sup> 62.7	61.5 <sup>5</sup> 51.3	46.6 <sup>3</sup> 40.1	71.2 <sup>4</sup> 63.6	60.7 <sup>1</sup> 41.3	47.1 <sup>19</sup> 50.8		68.1 <sup>6</sup> 54.1	64.9 <sup>6</sup> 53.5
W17	66.8 <sup>6</sup> 87.1	68.0 <sup>3</sup> 86.8	72.7 <sup>3</sup> 86.8	83.1 <sup>4</sup> 87.3	69.3 <sup>7</sup> 76.1	75.7 <sup>7</sup> 82.8	86.1 <sup>3</sup> 81.8	79.3 <sup>2</sup> 99.1	54.1 <sup>6</sup> 68.1		73.1 <sup>10</sup> 75.5
Ia. 939	61.2 <sup>7</sup> 86.8	68.0 <sup>3</sup> 85.8	72.7 <sup>3</sup> 85.8	83.1 <sup>4</sup> 87.3	69.3 <sup>7</sup> 72.5	75.7 <sup>7</sup> 79.8	86.1 <sup>3</sup> 81.6	68.7 <sup>4</sup> 96.5	53.5 <sup>6</sup> 64.9	75.5 <sup>10</sup> 73.1	

The difference in yield of 5.6 bushels per acre in favor of Waugh can be taken as indicating an inherent difference in productiveness, but the differences in percentage of moisture at harvest and in lodging are of doubtful significance for these two varieties. As a general statement, a yield difference of 5 or 6 bushels per acre is significant for any one experiment but only for the conditions of seed, soil, and weather prevailing in that particular experiment. Growth conditions may be especially favorable for one strain in one season and for another strain in the next. Very little importance can be placed on the results of any one experiment. In the cases where recommendations have been made on the data from only one season of testing, supporting data have been available on the performance of the parents in similar hybrids.

TABLE 2.—Percentage of Dry Matter in Ears at Harvest for Earlier Hybrids and Varieties

In each square the small figure (upper right corner) shows the number of direct comparisons between the corresponding strains at the top and left of the table. The other two values give percentage of dry matter; the upper value is that of the strain at the top of the table and the lower value is that of the strain at the left. **Example:** The respective dry matter of Medina Pride and Waugh in 17 comparative tests was 71.0 per cent for Medina Pride and 71.4 per cent for Waugh.

	Medina Pride	Waugh	Cook	K23	K24	Ia. 931	K35	Woos- ter Clar- age	Wood- burn	W17	Ia. 939
Medina Pride		71.4 <sup>17</sup> 71.0	67.9 <sup>9</sup> 69.8	67.1 <sup>8</sup> 69.8	60.6 <sup>4</sup> 65.6	68.6 <sup>8</sup> 70.3	60.8 <sup>1</sup> 61.1	68.4 <sup>17</sup> 72.1	73.1 <sup>20</sup> 75.9	60.2 <sup>6</sup> 67.1	67.5 <sup>7</sup> 71.9
Waugh	71.0 <sup>17</sup> 71.4		68.1 <sup>8</sup> 70.3	68.9 <sup>4</sup> 69.6	61.0 <sup>3</sup> 64.2	65.8 <sup>4</sup> 67.1	60.8 <sup>1</sup> 62.4	63.4 <sup>18</sup> 70.0	71.2 <sup>12</sup> 75.0	58.9 <sup>3</sup> 64.2	57.7 <sup>3</sup> 64.2
Cook	69.8 <sup>9</sup> 67.9	70.3 <sup>8</sup> 68.1		65.1 <sup>3</sup> 66.3	61.0 <sup>3</sup> 63.7	65.9 <sup>7</sup> 66.5	60.8 <sup>1</sup> 62.7	62.0 <sup>7</sup> 66.5	69.5 <sup>6</sup> 72.2	58.9 <sup>3</sup> 63.7	57.7 <sup>3</sup> 63.7
K23	69.8 <sup>8</sup> 67.1	69.6 <sup>4</sup> 68.9	66.3 <sup>3</sup> 65.1		64.6 <sup>4</sup> 66.0	67.7 <sup>5</sup> 67.5	70.1 <sup>2</sup> 71.0	61.7 <sup>3</sup> 65.1	73.7 <sup>5</sup> 74.9	63.0 <sup>4</sup> 66.0	63.7 <sup>4</sup> 66.0
K24	65.6 <sup>4</sup> 60.6	64.2 <sup>3</sup> 61.0	63.7 <sup>3</sup> 61.0	66.0 <sup>4</sup> 64.6		65.8 <sup>6</sup> 64.3	67.4 <sup>3</sup> 67.8	56.7 <sup>2</sup> 59.6	74.1 <sup>3</sup> 74.4	64.7 <sup>7</sup> 66.5	64.0 <sup>7</sup> 66.5
Ia. 931	70.3 <sup>8</sup> 68.6	67.1 <sup>4</sup> 65.8	66.5 <sup>7</sup> 65.9	67.5 <sup>5</sup> 67.7	64.3 <sup>6</sup> 65.8		67.4 <sup>3</sup> 68.3	68.4 <sup>6</sup> 70.1	67.4 <sup>4</sup> 70.3	63.3 <sup>7</sup> 66.8	63.0 <sup>7</sup> 66.8
K35	61.1 <sup>1</sup> 60.8	62.4 <sup>1</sup> 60.8	62.7 <sup>1</sup> 60.8	71.0 <sup>2</sup> 70.1	67.8 <sup>3</sup> 67.4	68.3 <sup>3</sup> 67.4		56.5 <sup>1</sup> 60.8	78.7 <sup>1</sup> 79.3	65.9 <sup>3</sup> 67.4	65.1 <sup>3</sup> 67.4
Wooster Clarage	72.1 <sup>37</sup> 68.4	70.0 <sup>13</sup> 63.4	66.5 <sup>7</sup> 62.0	65.1 <sup>3</sup> 61.7	59.6 <sup>2</sup> 56.7	70.1 <sup>6</sup> 68.4	60.8 <sup>1</sup> 56.5		73.3 <sup>19</sup> 72.1	57.8 <sup>2</sup> 56.7	71.2 <sup>4</sup> 68.7
Woodburn	75.9 <sup>29</sup> 73.1	75.0 <sup>12</sup> 71.2	72.2 <sup>6</sup> 69.5	74.9 <sup>5</sup> 73.7	74.4 <sup>3</sup> 74.1	70.3 <sup>4</sup> 67.4	79.3 <sup>1</sup> 78.7	72.1 <sup>19</sup> 73.3		68.0 <sup>6</sup> 70.9	76.0 <sup>6</sup> 73.5
W17	67.1 <sup>6</sup> 60.2	64.2 <sup>3</sup> 58.9	63.7 <sup>3</sup> 58.9	66.0 <sup>4</sup> 63.0	66.5 <sup>7</sup> 64.7	66.8 <sup>7</sup> 63.3	67.4 <sup>3</sup> 65.9	56.7 <sup>2</sup> 57.8	70.9 <sup>6</sup> 68.0		66.1 <sup>10</sup> 66.3
Ia. 939	71.9 <sup>7</sup> 67.5	64.2 <sup>8</sup> 57.7	63.7 <sup>3</sup> 57.7	66.0 <sup>4</sup> 63.7	66.5 <sup>7</sup> 64.0	66.8 <sup>7</sup> 63.0	67.4 <sup>3</sup> 65.1	68.7 <sup>4</sup> 71.2	73.5 <sup>6</sup> 76.0	66.3 <sup>10</sup> 66.1	

Among the open-pollinated varieties, Cook is outstanding in yield, having a decided advantage over both Wooster Clarage and Woodburn (Table 1) and at the same time being earlier than either, as is shown by the higher percentage of dry matter at harvest (Table 2). Cook, however, makes a poor showing against good hybrids. The consistent superiority of the hybrids over the varieties in both yield and lodge resistance is evident and needs no discussion.

In studying these data, it must be considered that in direct comparisons a later strain should produce more grain than an earlier competitor. This is true unless the translocation or grain filling period is seriously shortened in the later strain by the termination of the growing season. Such a condition rarely if ever occurred in the experiments reported here. The degree of earliness or lateness must be judged by the percentage of dry matter in the ears (dryness) at harvest (Tables 2 and 5). A real difference of only 1 per cent in this measure in these tables would indicate a difference in climatic adaptation north to south of at least one county. For instance, in 29 comparisons Medina Pride was higher than Woodburn in percentage of dry matter by 2.9 (Table 2) and in 21 comparisons Woodburn was higher than Eichelberger Clarage by 2.9 (Table 5). This combined difference of 5.8 covers a range of adaptation no smaller than from Medina to Clinton County. Unfortunately, dependable ranking in percentage of dry matter at harvest is difficult to get because of differential performance from one experiment to another, and decided inconsistencies can be found in the tables.

As an antidote for possible overzealous discrimination between these tested hybrids, it should be emphasized that none of them and, at least to the writer's knowledge, no other hybrids are altogether good. Nor are any of those reported in this paper thoroughly bad for their recommended areas. It is not attempted to enumerate even all the known differences. Hybrids may differ in ease of hand harvest, suitability for machine harvest, susceptibility to smut, rots, cold, heat, drouth, and insect damage, possibly even slightly in feeding value. But after all, if a strain of corn yields well, is right in seasonal requirement, and is standing at harvest, it is over the biggest hurdles.

A corn grower using hybrids for the first time will do well to try more than one adapted hybrid the first year and he should by all means include some of his favorite open-pollinated varieties in the same field with these hybrids, and under as nearly the same fertility conditions as possible.

#### NOTES ON HYBRIDS LISTED IN THE TABLES

The notes below give approximations of what may be expected under favorable growth conditions. They are necessarily relative. For instance, ear length may be described as short, medium short, medium, medium long, or long. Isolated statements in actual inches would be utterly confusing because of the variation dependent upon soil and season.

The remarks on adaptation represent what seems to be the best information to date. Some modifications may be necessary as further experience is gained. The location of the different adaptation areas is shown in Figure 1.

**Ohio K23** (65 x 84) (26 x 51) is adapted to better soils in Area 2, for general use in 3 East and 3 West, and for thinner soils or early corn in 4 and 5.

Its plants are short, very lodge resistant, deep green, leafy, tend to tiller, and have short shanks. The ears are low on the stalk, medium short, medium thick, and have 16 to 18 rows of tapering medium dented but rather sharp medium depth grain.

**Ohio K24** (65 x 51) (17 x 26) is similar in adaptation to K23. The plants are short, very lodge resistant, and tend to tiller. The ears are medium short, medium thick, smooth, and have large, medium shallow kernels.

**Iowa 931** (L289 x Cl447) (Os420 x Os426) has an adaptation similar to that of K23. Its plants are medium tall. The ears are medium long, medium slender, medium rough, and have 14 to 16 rows of medium shallow grain.

**Ohio K35** (65 x 02) (26 x Hy) is a very new hybrid, and its extent of adaptation is not well worked out. It is safe on better soils in Area 3 and for general planting in Areas 4 and 5.

The plants are medium high, and the ears are medium short, medium thick, and have 14 to 18 rows of medium dented, medium deep grain. The seed supply will be limited for both the 1938 and the 1939 crops.

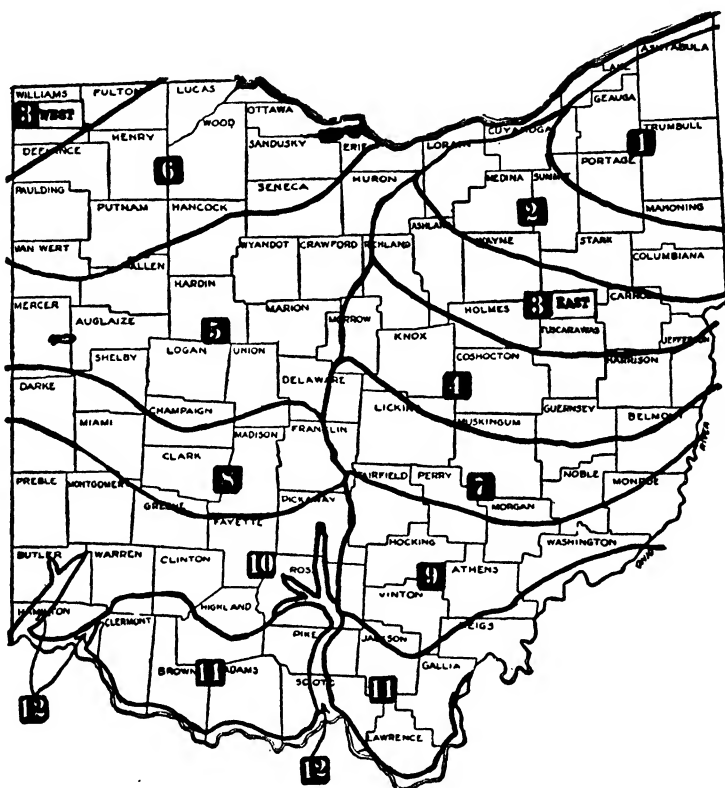


Fig. 1.—Adaptation areas for corn hybrids

**Ohio W17** (56 x 4-8) (51 x 84) is similar to Woodburn variety in adaptation. It is recommended for the best soils in Areas 3 East and 3 West, for good soils in Area 4, for general planting in Areas 5, 6, and 7, and for thinner upland soils in Areas 8, 9, and 10.

Its plants are leafy with short shanks and the ears are medium low, medium length, medium thick, large at the butt, smooth, and carry 16 to 18 rows of thick, shallow kernels.

Iowa 939 (Os420 x Os426) (L289 x I205) has an adaptation similar to that of Ohio W17.

The plants are medium tall with the ears at medium height. These ears are almost long, medium slender, medium rough, and have 16 rows of medium depth grain.

U. S. 52 (Ohio C72) (67 x Hy) (4-8 x 540) is earlier than it was estimated to be a year ago. It can now be recommended for harvesting from standing stalks or on better soil in Areas 6 and 7, and for general planting in Areas 8, 9, and 10.

TABLE 3.—Percentage of Lodged and Broken Plants for Earlier Hybrids and Varieties

In each square the small figure (upper right corner) shows the number of direct comparisons between the corresponding strains at the top and left of the table. The other two values give percentage of lodged and broken plants; the upper value is that of the strain at the top of the table and the lower value is that of the strain at the left. Example: The respective lodged and broken plants for Medina Pride and Waugh in seven comparative tests were 24.4 per cent for Medina Pride and 29.0 per cent for Waugh.

	Medina Pride	Waugh	Cook	K23	K24	Ia. 931	K35	Woos- ter Clarage	Wood- burn	W17	Ia. 939
Medina Pride		29.0 <sup>7</sup> 24.4	27.9 <sup>6</sup> 27.9	2.8 <sup>8</sup> 21.1	9.0 <sup>4</sup> 34.3	9.5 <sup>8</sup> 18.5	0.3 <sup>1</sup> 2.3	34.5 <sup>4</sup> 32.5	10.0 <sup>10</sup> 15.0	4.4 <sup>1</sup> 25.7	6.3 <sup>5</sup> 29.1
Waugh	24.4 <sup>7</sup> 29.0		27.9 <sup>6</sup> 33.8	5.2 <sup>4</sup> 29.9	11.3 <sup>3</sup> 44.5	11.5 <sup>4</sup> 33.8	0.3 <sup>1</sup> 50.4	34.5 <sup>4</sup> 39.8	13.4 <sup>6</sup> 17.2	8.0 <sup>3</sup> 44.5	9.1 <sup>8</sup> 44.5
Cook	27.9 <sup>6</sup> 27.9	33.8 <sup>6</sup> 27.9		6.5 <sup>3</sup> 34.2	11.3 <sup>3</sup> 36.7	9.2 <sup>7</sup> 22.4	0.3 <sup>1</sup> 34.2	34.5 <sup>4</sup> 34.9	8.9 <sup>5</sup> 13.3	8.0 <sup>3</sup> 36.7	9.1 <sup>8</sup> 36.7
K23	21.1 <sup>18</sup> 2.8	29.9 <sup>4</sup> 5.2	34.2 <sup>3</sup> 6.5		10.7 <sup>4</sup> 7.5	14.2 <sup>5</sup> 6.0	3.9 <sup>2</sup> 5.2	35.7 <sup>3</sup> 6.5	14.5 <sup>4</sup> 2.7	9.4 <sup>4</sup> 7.5	10.5 <sup>4</sup> 7.5
K24	34.3 <sup>4</sup> 9.0	44.5 <sup>3</sup> 11.3	36.7 <sup>3</sup> 11.3	7.5 <sup>4</sup> 10.7		15.4 <sup>6</sup> 8.2	4.5 <sup>3</sup> 5.1	52.7 <sup>2</sup> 15.4	26.3 <sup>3</sup> 4.8	6.3 <sup>7</sup> 7.2	7.4 <sup>7</sup> 7.2
Ia. 931	18.5 <sup>8</sup> 9.5	33.8 <sup>4</sup> 11.5	22.4 <sup>7</sup> 9.2	6.0 <sup>5</sup> 14.2	8.2 <sup>6</sup> 15.4		4.5 <sup>3</sup> 17.4	27.3 <sup>4</sup> 11.2	3.4 <sup>3</sup> 2.5	6.3 <sup>7</sup> 14.1	7.3 <sup>7</sup> 14.1
K35	2.3 <sup>1</sup> 0.3	50.4 <sup>1</sup> 0.3	34.2 <sup>1</sup> 0.3	5.2 <sup>2</sup> 3.9	5.1 <sup>3</sup> 4.5	17.4 <sup>3</sup> 4.5		35.1 <sup>1</sup> 0.3	43.2 <sup>1</sup> 7.5	7.6 <sup>3</sup> 4.5	11.3 <sup>3</sup> 4.5
Wooster Clarage	32.5 <sup>4</sup> 34.5	39.8 <sup>4</sup> 34.5	34.9 <sup>4</sup> 34.5	6.5 <sup>3</sup> 35.7	15.4 <sup>2</sup> 52.7	11.2 <sup>4</sup> 27.3	0.3 <sup>1</sup> 35.1		14.3 <sup>2</sup> 16.4	10.8 <sup>2</sup> 52.7	12.7 <sup>2</sup> 52.7
Woodburn	15.0 <sup>10</sup> 10.0	17.2 <sup>6</sup> 13.4	13.3 <sup>5</sup> 8.9	2.7 <sup>4</sup> 14.5	4.8 <sup>1</sup> 26.3	2.5 <sup>3</sup> 3.4	7.5 <sup>1</sup> 43.2	16.4 <sup>2</sup> 14.3		18.8 <sup>6</sup> 31.9	22.4 <sup>5</sup> 36.8
W17	25.7 <sup>6</sup> 4.4	44.5 <sup>3</sup> 8.0	36.7 <sup>3</sup> 8.0	7.5 <sup>4</sup> 9.4	7.2 <sup>7</sup> 6.3	14.1 <sup>7</sup> 6.3	4.5 <sup>3</sup> 7.6	52.7 <sup>2</sup> 10.8	31.9 <sup>6</sup> 18.8		15.1 <sup>10</sup> 14.4
Ia. 939	29.1 <sup>5</sup> 6.3	44.5 <sup>3</sup> 9.1	36.7 <sup>3</sup> 9.1	7.5 <sup>4</sup> 10.5	7.2 <sup>7</sup> 7.4	14.1 <sup>7</sup> 7.3	4.5 <sup>3</sup> 11.3	52.7 <sup>2</sup> 12.7	36.8 <sup>5</sup> 22.4	14.4 <sup>10</sup> 15.1	

Its plants are tall and very lodge resistant. The ears are borne medium high and are of medium length and thickness, smooth, and carry 16 to 18 rows of medium depth grain.

Illinois 172 (R4 x Hy) (A x 540) is similar in adaptation to U. S. 52. Its plants are medium tall. The ear is medium in length and thickness, smooth, and carries 18 to 20 rows of medium depth grain.

TABLE 4.—Comparative Grain Yield Data for Later Hybrids and Varieties  
(For interpretation see Table 1)

	Wood- burn	W17	U. S. 52	Ia. 939	Ill. 172	Ind. 614	U. S. 44	L31	Lan- caster	Eich. Clar- age	Krug
Woodburn		68.1 <sup>6</sup> 54.1	75.8 <sup>2</sup> 50.5	64.9 <sup>6</sup> 53.5	57.4 <sup>3</sup> 35.7	50.3 <sup>2</sup> 34.0	63.3 <sup>4</sup> 41.1	52.5 <sup>2</sup> 34.0	52.0 <sup>7</sup> 49.9	48.7 <sup>21</sup> 47.2	45.3 <sup>7</sup> 48.7
W17	54.1 <sup>6</sup> 68.1		71.6 <sup>2</sup> 67.2	73.1 <sup>10</sup> 75.2	48.7 <sup>1</sup> 56.8	56.1 <sup>1</sup> 56.8	68.9 <sup>3</sup> 71.5	61.3 <sup>2</sup> 68.6	36.0 <sup>1</sup> 56.8	45.0 <sup>2</sup> 59.2	56.0 <sup>1</sup> 77.5
U. S. 52	50.5 <sup>2</sup> 75.8	67.2 <sup>2</sup> 71.6		74.3 <sup>2</sup> 70.4	51.6 <sup>-</sup> 55.4	57.8 <sup>2</sup> 55.4	63.6 <sup>4</sup> 65.0	51.4 <sup>3</sup> 56.0	36.0 <sup>1</sup> 51.2	62.5 <sup>1</sup> 92.0	56.0 <sup>1</sup> 92.0
Ia. 939	53.5 <sup>6</sup> 64.9	75.5 <sup>10</sup> 73.1	70.4 <sup>2</sup> 74.3		48.7 <sup>1</sup> 50.4	56.1 <sup>1</sup> 50.4	68.9 <sup>3</sup> 70.8	61.3 <sup>2</sup> 62.6	36.0 <sup>1</sup> 50.4	67.9 <sup>2</sup> 92.6	56.0 <sup>1</sup> 87.3
Ill. 172	35.7 <sup>3</sup> 57.4	56.8 <sup>1</sup> 48.7	55.4 <sup>2</sup> 51.6	50.4 <sup>1</sup> 48.7		47.6 <sup>4</sup> 46.8	51.3 <sup>4</sup> 46.3	53.2 <sup>3</sup> 49.8	36.0 <sup>1</sup> 48.7		39.1 <sup>1</sup> 60.5
Ind. 614	34.0 <sup>2</sup> 50.3	56.8 <sup>1</sup> 56.1	55.4 <sup>2</sup> 57.8	50.4 <sup>1</sup> 56.1	46.8 <sup>4</sup> 47.6		51.3 <sup>4</sup> 47.6	53.2 <sup>3</sup> 52.2	36.0 <sup>1</sup> 56.1	27.5 <sup>1</sup> 33.7	
U. S. 44	41.1 <sup>4</sup> 63.3	71.5 <sup>3</sup> 68.9	65.0 <sup>4</sup> 63.6	70.8 <sup>3</sup> 68.9	46.8 <sup>4</sup> 51.3	47.6 <sup>4</sup> 51.3		54.1 <sup>5</sup> 57.7	36.0 <sup>1</sup> 52.6	42.8 <sup>3</sup> 60.9	56.0 <sup>1</sup> 85.3
L31	34.0 <sup>2</sup> 52.5	68.6 <sup>2</sup> 61.3	56.0 <sup>1</sup> 51.4	62.6 <sup>2</sup> 61.3	49.8 <sup>3</sup> 53.2	52.2 <sup>3</sup> 53.2	57.7 <sup>5</sup> 54.1		36.0 <sup>1</sup> 54.8		
Lancaster	49.9 <sup>7</sup> 52.0	56.8 <sup>1</sup> 36.0	51.2 <sup>1</sup> 36.0	50.4 <sup>1</sup> 36.0	48.7 <sup>1</sup> 36.0	56.1 <sup>1</sup> 36.0	52.6 <sup>1</sup> 36.0	54.8 <sup>1</sup> 36.0		52.8 <sup>8</sup> 59.3	48.5 <sup>8</sup> 52.4
Eich. Clarage	47.2 <sup>21</sup> 48.7	59.2 <sup>2</sup> 45.0	92.0 <sup>1</sup> 62.5	92.6 <sup>2</sup> 67.9		33.7 <sup>1</sup> 27.5	60.9 <sup>3</sup> 42.8		59.3 <sup>8</sup> 52.8		47.3 <sup>6</sup> 50.3
Krug	48.7 <sup>7</sup> 45.3	77.5 <sup>1</sup> 56.0	92.0 <sup>1</sup> 56.0	87.3 <sup>1</sup> 56.0	60.5 <sup>1</sup> 39.1		85.3 <sup>1</sup> 56.0		52.4 <sup>3</sup> 48.5	50.3 <sup>6</sup> 47.3	

Indiana 614 (Illinois 392) (A x Hy) (R4 x Tr), although it has been successfully grown in Area 6, needs further testing of its adaptation there. It is adapted to highly productive bottom soils in Area 7, to good soils in 8 and 9, and for general planting in 10 and 11.

The plants are short to medium height, and the ears are medium short, medium thick, medium rough, and have 18 to 20 rows of medium deep grain.

U. S. 44 (187 x 4-8) (Hy x 540) is another hybrid which is earlier than the first recommendations indicated. It can be recommended for the same areas and soils as Indiana 614.

Its plants are short to medium in height and very lodge resistant. The ears are medium long, medium slender, very smooth, and carry 18 to 20 rows of shallow grain.

**Ohio L31** (10 x Tr) (67 x L317) is adapted for best soils in Areas 9 and 10 and for general planting in Area 11.

Its plants are medium tall, and its ears are of medium length and thickness, medium rough, and carry 16 to 18 rows of medium deep grain.

### NOTES ON HYBRIDS NOT INCLUDED IN THE TABLES

**U. S. 65 (Ohio C51)** (51 x 4-8) (Hy x 540) is tentatively placed in the same maturity class as U. S. 52. The seasonal requirements of the inbred parents would place it earlier than U. S. 52, and it was slightly earlier and slightly more productive in 1 year's test in Ohio. Uniform field tests across the Corn Belt give it a high rating.

**TABLE 5.—Percentage of Dry Matter in Ears at Harvest for Later Hybrids and Varieties**  
(For interpretation see Table 2)

	Woodburn	W17	U. S. 52	Ia. 939	Ill. 172	Ind. 614	U. S. 44	L31	Lancaster	Eich. Clarage	Krug
Woodburn		68.0 <sup>6</sup> 70.9	72.1 <sup>2</sup> 71.5	76.0 <sup>6</sup> 73.5	69.0 <sup>3</sup> 70.0	69.0 <sup>2</sup> 74.3	68.1 <sup>4</sup> 71.8	67.6 <sup>2</sup> 74.3	69.1 <sup>7</sup> 73.6	71.7 <sup>21</sup> 74.6	66.5 <sup>7</sup> 69.9
W17	70.9 <sup>6</sup> 68.0		70.4 <sup>2</sup> 70.9	56.1 <sup>10</sup> 66.3	72.1 <sup>1</sup> 75.3	71.9 <sup>1</sup> 75.3	65.1 <sup>3</sup> 67.9	65.5 <sup>2</sup> 68.7	72.7 <sup>1</sup> 75.3	71.8 <sup>2</sup> 72.4	66.8 <sup>1</sup> 66.5
U. S. 52	71.5 <sup>2</sup> 72.1	70.9 <sup>2</sup> 70.4		68.9 <sup>2</sup> 71.6	74.3 <sup>2</sup> 74.1	72.4 <sup>2</sup> 74.1	71.3 <sup>4</sup> 73.0	71.4 <sup>3</sup> 74.5	72.7 <sup>1</sup> 72.4	65.8 <sup>1</sup> 68.4	66.8 <sup>1</sup> 68.4
Ia. 939	73.5 <sup>6</sup> 76.0	66.3 <sup>10</sup> 66.1	71.6 <sup>2</sup> 68.9		72.1 <sup>1</sup> 75.2	71.9 <sup>1</sup> 75.2		65.5 <sup>2</sup> 66.7	72.7 <sup>1</sup> 75.2	73.0 <sup>2</sup> 76.1	66.8 <sup>1</sup> 66.8
Ill. 172	70.0 <sup>3</sup> 69.0	75.3 <sup>1</sup> 72.1	74.1 <sup>2</sup> 74.3	75.2 <sup>1</sup> 72.1		72.4 <sup>4</sup> 74.2	72.9 <sup>4</sup> 74.2	69.0 <sup>3</sup> 72.3	72.7 <sup>1</sup> 72.1		60.3 <sup>1</sup> 63.1
Ind. 614	74.3 <sup>2</sup> 69.0	75.3 <sup>1</sup> 71.9	74.1 <sup>2</sup> 72.4	75.2 <sup>1</sup> 71.9	74.2 <sup>4</sup> 72.4		72.9 <sup>4</sup> 72.4	69.0 <sup>3</sup> 69.9	72.7 <sup>1</sup> 71.9	77.7 <sup>1</sup> 79.9	
U. S. 44	71.8 <sup>4</sup> 68.1	67.9 <sup>3</sup> 65.1	73.0 <sup>4</sup> 71.3		74.2 <sup>4</sup> 72.9	72.4 <sup>4</sup> 72.9		67.7 <sup>5</sup> 68.6	72.7 <sup>1</sup> 71.5	70.6 <sup>3</sup> 70.2	66.8 <sup>1</sup> 66.6
L31	74.3 <sup>2</sup> 67.6	68.7 <sup>2</sup> 65.5	74.5 <sup>3</sup> 71.4	66.7 <sup>2</sup> 65.5	72.3 <sup>3</sup> 69.0	69.9 <sup>3</sup> 69.0	68.6 <sup>5</sup> 67.7		72.7 <sup>1</sup> 71.8		
Lancaster	73.6 <sup>7</sup> 69.1	75.3 <sup>1</sup> 72.7	72.4 <sup>1</sup> 72.7	75.2 <sup>1</sup> 72.7	72.1 <sup>1</sup> 72.7	71.9 <sup>1</sup> 72.7	71.5 <sup>1</sup> 72.7	71.8 <sup>1</sup> 72.7		71.2 <sup>8</sup> 69.5	67.5 <sup>3</sup> 67.2
Eich. Clarage	74.6 <sup>21</sup> 71.7	72.4 <sup>2</sup> 71.8	68.4 <sup>1</sup> 65.8	76.1 <sup>2</sup> 73.0		79.9 <sup>1</sup> 77.7	70.2 <sup>8</sup> 70.6		69.5 <sup>8</sup> 71.2		66.4 <sup>6</sup> 67.8
Krug	69.9 <sup>7</sup> 66.5	66.5 <sup>1</sup> 66.8	68.4 <sup>1</sup> 66.8	66.8 <sup>1</sup> 66.8	63.1 <sup>1</sup> 60.3		66.6 <sup>1</sup> 66.8		67.2 <sup>8</sup> 67.5	67.8 <sup>6</sup> 66.4	

Its plants are tall, and have ears of medium length and thickness, smooth, with 16 to 18 rows of medium depth grain.

Illinois 384 (A x Hy) (WF9 x R4) differs from Indiana 614 by the substitution of line WF9 for line Tr. The substituted line is earlier and more resistant to lodging than line Tr. This hybrid has been widely grown in Illinois. Preliminary tests in Ohio would rate it as good. Its adaptation is similar to that of U. S. 52.

Its plants are medium short. Its ears are of medium length and thickness, smooth, and have 18 to 20 rows of medium deep grain.

**TABLE 6.—Percentage of Lodged and Broken Plants for  
Later Hybrids and Varieties**  
(For interpretation see Table 3)

	Wood- burn	W17	U. S. 52	Ia. 939	Ill. 172	Ind. 614	U. S. 44	L31	Lan- caster	Eich. Clar- age	Krug
Woodburn		18.8 <sup>6</sup> 31.9	45.5 <sup>2</sup> 74.3	22.4 <sup>1</sup> 36.8	6.3 <sup>2</sup> 32.6	9.8 <sup>2</sup> 32.6	31.3 <sup>4</sup> 56.0	35.0 <sup>2</sup> 32.6	14.7 <sup>2</sup> 13.1	78.9 <sup>2</sup> 79.4	52.6 <sup>3</sup> 50.2
W17	31.9 <sup>6</sup> 18.8		41.1 <sup>2</sup> 49.8	15.1 <sup>10</sup> 14.4	4.8 <sup>1</sup> 5.5	4.1 <sup>1</sup> 5.5	30.6 <sup>1</sup> 34.3	7.4 <sup>2</sup> 4.4	8.6 <sup>1</sup> 5.5	61.9 <sup>2</sup> 47.4	100.0 <sup>1</sup> 94.1
U. S. 52	74.3 <sup>2</sup> 45.5	49.8 <sup>2</sup> 41.1		48.9 <sup>2</sup> 41.1	6.9 <sup>2</sup> 4.8	10.3 <sup>2</sup> 4.8	25.5 <sup>4</sup> 23.3	19.0 <sup>3</sup> 3.8	8.6 <sup>1</sup> 0.3	84.4 <sup>1</sup> 81.8	100.0 <sup>1</sup> 81.8
Ia. 939	36.8 <sup>5</sup> 22.4	14.4 <sup>10</sup> 15.1	41.1 <sup>2</sup> 48.9		4.8 <sup>1</sup> 5.2	4.1 <sup>1</sup> 5.2		7.4 <sup>2</sup> 5.4	8.6 <sup>1</sup> 5.2	84.4 <sup>1</sup> 92.6	100.0 <sup>1</sup> 92.6
Ill. 172	32.6 <sup>2</sup> 6.3	5.5 <sup>1</sup> 4.8	4.8 <sup>2</sup> 6.9	5.2 <sup>1</sup> 4.8		11.3 <sup>4</sup> 10.7	6.8 <sup>4</sup> 10.7	35.3 <sup>3</sup> 5.8	8.6 <sup>1</sup> 4.8		5.4 <sup>1</sup> 0.0
Ind. 614	32.6 <sup>2</sup> 9.8	5.5 <sup>1</sup> 4.1	4.8 <sup>2</sup> 10.3	5.2 <sup>1</sup> 4.1	10.7 <sup>4</sup> 11.3		11.3 <sup>4</sup> 6.8	25.3 <sup>3</sup> 7.9	8.6 <sup>1</sup> 4.1	39.3 <sup>1</sup> 21.7	
U. S. 44	56.0 <sup>4</sup> 31.3	34.3 <sup>3</sup> 30.6	23.3 <sup>4</sup> 26.5		10.7 <sup>4</sup> 6.8	6.8 <sup>4</sup> 11.3		17.8 <sup>5</sup> 3.9	8.6 <sup>1</sup> 1.3	65.7 <sup>3</sup> 41.1	100.0 <sup>1</sup> 89.2
L31	32.6 <sup>2</sup> 35.0	4.4 <sup>2</sup> 7.4	3.8 <sup>3</sup> 19.0	5.4 <sup>2</sup> 7.4	5.8 <sup>3</sup> 35.3	7.9 <sup>3</sup> 25.3	3.9 <sup>5</sup> 17.8		8.6 <sup>1</sup> 5.8		
Lancaster	13.1 <sup>2</sup> 14.7	5.5 <sup>1</sup> 8.6	0.3 <sup>1</sup> 8.6	5.2 <sup>1</sup> 8.6	4.8 <sup>1</sup> 8.6	4.1 <sup>1</sup> 8.6	1.3 <sup>1</sup> 8.6	5.8 <sup>1</sup> 8.6			
Eich. Clarage	79.4 <sup>2</sup> 78.9	47.4 <sup>2</sup> 61.9	81.8 <sup>1</sup> 84.4	92.6 <sup>1</sup> 84.4		21.7 <sup>1</sup> 39.3	41.1 <sup>3</sup> 65.7				100.0 <sup>1</sup> 84.4
Krug	50.2 <sup>8</sup> 52.6	94.1 <sup>1</sup> 100.0	81.8 <sup>1</sup> 100.0	92.6 <sup>1</sup> 100.0	0.0 <sup>1</sup> 5.4		89.2 <sup>1</sup> 100.0			84.4 <sup>1</sup> 100.0	

**Hi-Bred 301<sup>a</sup>** in 20 experiments ranging from Wayne to Hamilton County has an average excess yield of 8 bushels per acre over good open-pollinated varieties. It is suitable for general planting in Areas 8 and 10, and for better soils in 7 and 9.

The plants are medium tall, and the ears are medium long, of medium thickness, medium smooth, and carry 18 rows of medium depth grain.

**Hi-Bred 311A<sup>a</sup>** was tested in Franklin and Belmont Counties in 1935. A mis-shipment of seed prevented a more inclusive testing in 1936. Preliminary tests indicate it to be slightly earlier than Woodburn variety and among the best in its maturity class in productiveness.

It is adapted to the areas recommended for Ohio W17.

Its plants are medium tall and have medium long, medium slender, medium smooth ears that carry 16 rows of medium deep grain.

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<sup>a</sup>The writer is indebted to Chas. A. Nosker of the Ohio Hi-Bred Corn Company for plant and ear descriptions of Hi-Bred 301 and 311A.

## COOPERATIVE EXPERIMENTS IN PASTURE IMPROVEMENT

D. E. DODD

The more than 5,000,000 acres of permanent pasture on Ohio farms provide one of the chief sources and the most economical supply of livestock feed. Farmers are, therefore, much interested in any means that will increase the production or improve the quality of these pastures.

Experiments with fertilizers on pasture have been in progress for a number of years at several of the experiment station farms in Ohio, but these tests do not give very definite evidence as to what results might be expected under farm pasture conditions and on soil types different from those at the station farms. Accordingly, in 1931, 43 tests were begun in cooperation with the Ohio Agricultural Extension Service and Ohio farmers in various counties of eastern and southern Ohio. Additional tests were started in succeeding years and a few of the older tests were dropped as they became valueless for the purpose for which they had been established. Thus, the number of sets of data available from year to year has varied from a low of 30 in 1934 to a high of 71 in 1937.

In order to limit the test area as nearly as possible to one soil type and make the results from treatments comparable one with another, long, narrow plots 136 feet by 8 feet were used. Wherever sloping land was involved the plots extended up and down the slope at right angles to the contour. Although there was a wide range in the original productivity level of the various tests an attempt was made to keep away from areas too steep or badly eroded to make good pasture or too productive to show further improvement. The tests involved may be regarded as representing the average hill and rolling land pasture of the section.

Lime was applied to all plots uniformly where the pH level was below 5.8. Previous observations had shown this to be a first essential to proper response of the various fertilizers.

Both the lime and fertilizer treatments were applied to the surface. Grazing was uncontrolled and in common with the remainder of the field, except for the harvest areas.

During the first 4 years yields were determined by a 1 square yard harvest per plot about June 10 on an area protected from grazing. From this the yield per acre was calculated on the assumption that the June 10 harvest represented 60 per cent of the season's production. Different areas were used each year. During these same 4 years estimates were made on the probable production. These estimates were correlated with the actual yields and used as a basis for estimating yields in 1935, 1936, and 1937. It is recognized that such technique does not give very accurate figures, but with the number of tests involved it is felt that the data obtained are relatively dependable.

The various treatments and the yields per acre are given in Table 1. In the last two columns the 7-year average yield has been divided into desirable and undesirable herbage by means of the percentage of various types of herbage that constituted the vegetation present with the various treatments and years as indicated in Table 2, which also gives the percentage of the ground area unoccupied. The desirable herbage contains all so-called tame grass and

TABLE 1.—Plan of Treatments and Season's Yield in Pounds per Acre of Dry Matter on Oven-dry Basis  
By plots and years

Plot No.	Plot treatments in pounds per acre	1931	1932	1933	1934	1935*	1936*	1937*	Seven-year average		
									Total	Desirable	Undesirable
	Number of tests included in average <del>1937</del>	43	36	34	30	64	62	71			
8	Check, no fertilizer treatment .....	1473	2344	2494	1318	1424	1845	1250	1735	1017	718
3	600 lb. of 20 per cent superphosphate in spring of 1931 and 1935 .....	1905	3183	3807	1597	2916	3133	3113	2808	2171	637
2	600 lb. of 20 per cent superphosphate in spring of 1931 and 1935 .....	2249	3180	3798	1864	2930	3106	3143	2896	2273	623
	160 lb. of muriate of potash in spring of 1931 and 1935 .....										
1	600 lb. of 20 per cent superphosphate in spring of 1931 and 1935 .....	3920	3988	5074	2667	4867	3805	4745	4152	3418	734
	250 lb. of sulfate of ammonia annually .....										
4	600 lb. of 20 per cent superphosphate in spring of 1931 and 1935 .....	4116	4516	5816	2743	5186	3860	4910	4450	3791	659
	40 lb. of muriate of potash in spring of 1931 and 1935 .....										
	250 lb. of sulfate of ammonia annually .....	3824	4160	5835	3104	4914	3580	4584	4286	3639	647
6†	150 lb. of 20 per cent superphosphate annually, 1931 to 1934 .....										
	40 lb. of muriate of potash annually, 1931 to 1934 .....	3241	3756	4883	2702	4240	3376	4385	3798	3168	630
5	600 lb. of 20 per cent superphosphate in spring of 1931 and 1935 .....										
	160 lb. of muriate of potash in spring of 1931 and 1935 .....	3007	3829	4430	2434	4020	3279	3392	3484	2623	861
7	125 lb. of sulfate of ammonia annually .....										
	250 lb. of sulfate of ammonia annually .....										

\*Estimated.

†Beginning in 1935, the treatment was similar to No. 4, except that 227 lb. of Cyanamid has supplied the nitrogen.

Lime was used on all plots, including check, where tests indicated a deficiency. The estimated yield on adjoining areas without lime or fertilizer was 1000 to 1200 lb.

clover and consists largely of Kentucky bluegrass (*Poa pratensis*) and white clover (*Trifolium repens*). The undesirable herbage contains all so-called wild grass and weeds and consists chiefly of broom sedge (*Andropogon*), poverty grass (*Danthonia*), cinquefoil (*Potentilla*), triple awn grass (*Aristida*), daisy (*Chrysanthemum*), and various plantains (*Plantago*). (See Fig. 1).

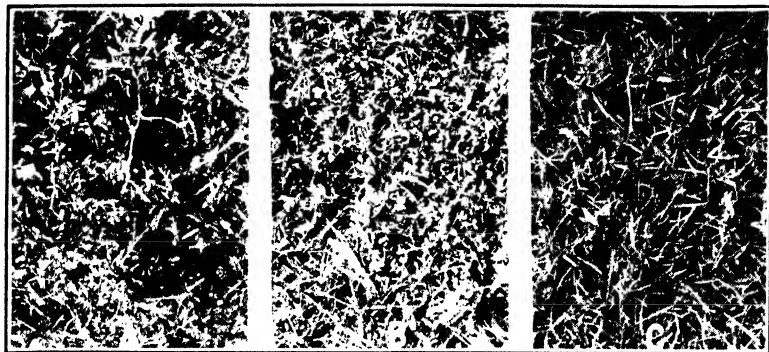


Fig. 1.—Mrs. Ray Stoltz Test, Perry County

A—No treatment

B—Lime and phosphate

C—Lime, nitrogen, phosphate, and potash

The livestock declined to graze the no-treatment area but have eaten the vegetation on the treated areas. Note the increase in clover on B and in grass on C.

### EQUIVALENT PRODUCTION AND RETURNS

A summary of production with equivalents in ewe and lamb grazing days, meat and milk, and returns per acre is given in Table 3. In this table it has been assumed that undesirable herbage had, for grazing purposes, one-half the value of desirable herbage; that all desirable herbage was equal; and that all undesirable herbage was likewise equal. We do not know what differences exist, but we do know that this assumption gives an undue advantage to the herbage of untreated areas. The livestock showed a distinct preference for the herbage from the fertilized plots even where the same species of plants were present (see Fig. 2).

It has been shown repeatedly in other experiments (1) that the additions of mineral fertilizers effect desirable changes in the mineral content of herbage. Furthermore, the clover content of the check plots averaged about 12 per cent; that of the phosphate alone, about 20 per cent; and that from the nitrogen-phosphate-potash plot, about 14 per cent. Although it is very evident that distinct differences exist, our information is not sufficient to provide a basis for a differential factor.

In all pasture there is an overhead cost for fence, taxes, and miscellaneous pasture activities. In these tests lime was used where needed on checks and treated plots alike. Therefore, in Table 3 a uniform overhead charge of \$2.00 per acre has been made covering all of these items.

1. Pierre, W. H. and R. R. Robinson. 1937. The calcium and phosphorus content of pasture herbage and of various pasture species as affected by fertilization and liming. Jour. Amer. Soc. Agron. 29: 477-497.

TABLE 2.—Percentage of Land Area of the Different Plots Occupied by Various Types of Herbage for the Years 1933-1937. Readings Made in May or Early June

Plot No.	Clover					Tame grass					Wild grass					Weeds					Bare ground				
	1933	1934	1935	1936	1937	1933	1934	1935	1936	1937	1933	1934	1935	1936	1937	1933	1934	1935	1936	1937	1933	1934	1935	1936	1937
8.....	16	14	9	18	1	44	52	48	40	50	13	12	17	19	13	27	22	26	23	36	30	35	47	35	44
3.....	26	21	15	33	3	52	58	61	49	71	7	7	9	10	5	15	14	15	10	21	16	20	28	15	28
2.....	30	21	15	32	3	50	60	62	49	71	5	6	8	9	5	15	13	15	10	21	14	20	27	15	28
1.....	19	15	9	26	2	64	73	73	56	77	4	3	6	9	4	13	9	12	9	17	8	12	20	9	20
4.....	20	16	9	24	2	65	73	77	59	81	3	3	5	9	3	11	8	9	8	14	5	10	14	6	19
6.....	22	17	8	27	2	65	73	76	55	80	3	3	6	9	2	10	7	10	9	16	4	10	16	7	21
5.....	24	19	9	28	2	60	68	75	54	79	4	5	6	10	3	12	8	10	8	16	8	12	11	7	21
7.....	12	9	5	15	1	65	69	70	59	72	7	8	8	12	5	16	14	17	14	22	17	22	27	19	29

TABLE 3.—Treatments, Cost, Yields of Herbage, Total Digestible Nutrients Available for Equivalent Production, the Equivalent Production in Terms of Ewe and Lamb Grazing Days, Beef and Milk, Pasture Cost per Unit of Production, and Value of Beef and Milk Above Cost of Treatment and Pasture Overhead

All figures are on the acre basis

Plot No.	Fertilizer treatment	Average annual cost of fertilizer treatment	Pounds of herbage	Total digestible nutrients available for equivalent production	Equivalent production					Value of beef or milk		
					Grazing days for one 130-pound ewe and lamb	Pasture cost per ewe and lamb grazing day*	Pounds of beef	Pounds of 100 heads of beef†	Pasture cost per 100 heads of milk*	Pounds of milk	Gross with	Over cost of treatment and pasture overhead
											Beef at \$7.00 per 100	Milk at \$1.75 per 100
8	None .....	Dol. 0.00	1735	743	265	Cents 0.755	135	Dol. 1.48	Dol. 0.19	1078	Dol. 9.45	Dol. 18.87
3	Phosphate. ....	2.08	2808	1344	480	0.850	244	1.67	0.21	1950	17.08	34.13
2	Phosphate. Potash .....	3.04	2896	1396	499	1.010	238	2.11	0.25	2026	16.66	35.46
1	Nitrogen Phosphate. Potash .....	6.95	4152	2044	730	1.226	371	2.41	0.30	2967	25.97	51.92
4	Nitrogen Phosphate. Potash .....	7.91	4450	2225	795	1.247	404	2.45	0.31	3229	28.28	56.51
6†	Nitrogen Phosphate. Potash .....	7.76	4286	2140	764	1.277	389	2.50	0.31	3106	27.23	54.36
5	One-half nitrogen Phosphate. Potash .....	5.66	3798	1881	672	1.140	342	2.23	0.28	2730	23.94	46.78
7	Nitrogen .....	5.00	3464	1649	589	1.188	299	2.34	0.29	2393	20.93	41.88

\*An overhead of \$2.00 per acre has been added to cost of fertilizer treatment in calculating the pasture cost and returns above pasture cost. This \$2.00 includes taxes, fences, miscellaneous pasture costs, and the cost of lime, which, in this experiment, was applied where needed to all plots alike, including check.

†On this plot the phosphate and potash were, during the first 4 years, applied annually instead of all at one time at the beginning of the 4-year period as in the case of the other plots. During the last 3 years the nitrogen has been in the form of Cyanamid; whereas on Plot 4 and other plots, it has been in the form of sulfate of ammonia.

According to Morrison (2), high-quality pasture carries approximately 72 pounds of total digestible nutrients per each 100 pounds of herbage on a dry basis. Several hundred analyses at the Ohio Experiment Station of pasture herbage similar to that involved in these tests indicate that this herbage is comparable to that referred to by Morrison and that Morrison's figure may safely be used in these calculations. However, grazing experiments at the West Virginia (3), Pennsylvania (4), and other experiment stations indicate that probably only about 75 per cent of the herbage produced is utilized by the livestock. Since this is true, 54 per cent of the total of the desirable herbage and one-half of the undesirable give the total digestible nutrients that might enter into the production of mutton, beef, or milk. From Morrison's tables it appears that 2.8 pounds of total digestible nutrients will support one 130-pound



Fig. 2.—The area of treated plots is indicated by black line. The cows knew the difference.  
Ray Davis Test, Jackson County, Ohio

ewe and nursing lamb 1 day and that 0.689 pound of total digestible nutrients is required to produce 1 pound of milk with cows averaging 1000 pounds in weight and producing an average of 20 pounds of milk a day. In the case of beef cattle, the same source of evidence indicates that growing animals may use anywhere from 3 to 7 pounds of digestible nutrients per pound of gain. The amount depends upon the age and condition of the animal. In Table 3 it has been assumed that on the average 5.5 pounds would be used per pound of beef produced. By applying these factors to the digestible nutrients that might enter into such production, we obtain the equivalent ewe and lamb grazing days, and the beef and milk production given in Table 3.

It is recognized that since three times as much area must be grazed by an animal on the untreated area as on the most productive treated area in order to obtain the same amount of nutrients, more energy would be consumed in the process of grazing the untreated. Since this difference is not known, it has been ignored in Table 3, but it is possible that the actual production of mutton, beef, or milk on the untreated area might not be more than one-half or three-fourths the amount indicated. This is important to keep in mind, since without this correction it appears that the untreated pasture produces digestible nutri-

2. Morrison, F. B. 1936. Feeds and Feeding, Twentieth Edition. The Morrison Publishing Company.

3. Robinson, R. R., W. H. Pierre, and R. A. Ackerman. 1937. A comparison of grazing and clipping for determining the response of permanent pastures to fertilization. Jour. Amer. Soc. Agron. 29: 349-359.

4. Gardner, F. D. et al. 1935. Pasture fertilization. Pa. Agr. Exp. Sta. Bull. 323.

ents at the lowest cost; whereas this probably is not true. It would probably be more nearly correct to assume that the pasture cost of the untreated area is 25 to 35 per cent higher than that on the phosphate-treated area.

### THE EFFECT OF WHITE CLOVER CONTENT ON HERBAGE, YIELD, AND POSSIBLE RETURNS

The effect of a high clover content has been to bring about a higher return from phosphate. For example, in 1935, there was generally a rather low content of clover, but the 12 sets of plots containing the highest clover content were picked out and compared with the remainder. These high clover tests, with 30 per cent of clover in the case of the phosphate plot, showed an average increase for phosphate over the check plot of 1525 pounds; whereas the increase was only 1374 pounds on the remainder where the clover content of the phosphate plot was only 6 per cent. In 1936 there were many tests where white clover was very prevalent. The 26 carrying the highest clover content, 46 per cent in the case of the phosphate plot, showed a gain for phosphate of 1362 pounds and the 18 with the lowest clover content, 17 per cent, only 611 pounds. If we average the returns from phosphate for these selected tests in 1935 and 1936 we find the average increase to be 1444 pounds where a high clover content was present and 993 pounds where a low clover content prevailed.

On the other hand, the average return for 1935 and 1936 for 50 pounds of nitrogen, applied in addition to phosphate, was 875 pounds where a high clover content was present and 1574 pounds where a low clover content was present. The nitrogen was 80 per cent more efficient in the absence of abundant clover. Thus, the presence of a high content of clover increased over a low content of clover the efficiency of phosphate by 45.4 per cent but decreased the effectiveness of nitrogen by 44.4 per cent.

If, in these high clover tests for 1935 and 1936, we compare the increases resulting from phosphate alone and phosphate and nitrogen combined, we find that the phosphate was 62.3 per cent as effective as the two combined. On the other hand, if we make a like comparison on the low clover tests, the phosphate alone was only 38.7 per cent as effective as the two combined. Now if we take the 7-year average yield of total digestible nutrients on the nitrogen-phosphate plot and, by applying these percentages, establish comparable yields for the high and low clover groups, we obtain the interesting comparisons indicated in Table 4. Such procedure of course does not give us absolute values, but it can be depended upon to reflect definite tendencies.

The conclusions to be drawn from such a comparison seem obvious. Where a high clover content can be maintained, phosphate alone lowers the cost and greatly increases the returns. Nitrogen in addition produces small returns and greatly increases the cost. On the other hand, where conditions are such that clover cannot be grown, phosphate alone raises the cost per unit of production and is less effective in increasing returns. The addition of nitrogen in this case is very effective in increasing returns and does not so greatly increase the cost per unit of production. The clover content is greatly affected by soil type and weather conditions. At no time during these tests was white clover seriously injured by winter conditions. However, in 1934 and again in 1936 it was seriously reduced and in many instances completely killed by hot dry summers. Nevertheless, it came back from seed, showing up early in the following years. Although there are locations and conditions under which a good white clover

TABLE 4.—Total Digestible Nutrients Available for Production, Equivalent Production in Terms of Ewe and Lamb Grazing Days, Beef, and Milk, Pasture Cost per Unit of Production, and Value of Beef and Milk Above Cost of Treatment and Pasture Overhead for Standard Chec and Nitrogen-phosphate Plots and for High and Low Clover Phosphate Plots, as Calculated from Selected Groups in 1935 and 1936

All figures are on the acre basis

Treatment*	Total digest- ible nutrients available for production	Equivalent production					Value of beef or milk			
		Grazing days per 130-pound ewe and lamb	Pasture cost per ewe and lamb graz- ing day	Pounds of beef	Pasture cost per 100 pounds of beef	Pounds of milk	Pasture cost per 100 pounds of milk	Gross with		Over cost of treat- ment and pasture overhead
								Beef at \$7.00 per 100	Milk at \$1.75 per 100	
None—Plot 8. All tests .....	743	265	Cents 0.755	135	Dol. 1.48	1078	Dol. 0.19	Dol. 9.45	Dol. 18.87	Dol. 7.45
High clover. Phosphate .....	1554	555	0.735	280	1.45	2255	0.18	19.60	39.46	15.52
Plot 3—Phosphate. All tests.	1344	480	0.850	244	1.67	1950	0.21	17.08	34.13	13.00
Low clover. Phosphate.....	1246	445	0.899	226	1.80	1809	0.23	15.82	31.66	11.74
Plot 1—Nitrogen, phosphate All tests .....	2044	730	1.226	371	2.41	2967	0.30	25.97	51.92	17.02

\*A uniform application of lime was made on all plots on these test areas showing a lime requirement.

content cannot be maintained, it has been repeatedly observed during this investigation that management frequently has been the chief factor limiting the clover content on pastures that have been properly limed and fertilized. Obviously, the advisable farm procedure is to so manage the pasture that an optimum white clover content may be maintained. Other experiments now in progress at the Ohio Agricultural Experiment Station seem to indicate that the herbage should be protected from both over- and undergrazing and maintained at a height ranging from 1½ to 5 or 6 inches. (See Fig. 2).

### FURTHER FERTILIZER EFFECTS

The effects of phosphate and nitrogen have come in for a rather extensive indirect discussion under the head of white clover. It is, however, of further interest that in 1937 all treatment of phosphate or phosphate and potash, with or without nitrogen, outyielded the 7-year average; whereas the check and nitrogen-alone treatment fell behind the 7-year average. This would seem to indicate the unsoundness of a nitrogen-alone program and probably a tendency for grazed areas without treatment to decline in production with successive years; whereas those with sufficient mineral treatment gradually improve. The first year of the test, phosphate-treated plots on the average outyielded the check plots by 432 pounds, or 29 per cent; the seventh year, by 1863 pounds, or 149 per cent. There appears in these tests to be little justification, in the area represented, for potash in addition to phosphate unless nitrogen also is supplied. Under this latter condition, the potash has been a good investment.



Fig. 3.—Good land use. Rolling land in pasture and meadow.  
H. A. Studor Farm, Muskingum County, Ohio

As an average for the 7 years, the addition of 50 pounds of nitrogen annually to either the phosphate or phosphate-potash plots has given good returns. In fact, although the largest return per dollar invested has come from phosphate alone, the highest net return has come from the plots receiving the heaviest applications of nitrogen in addition to phosphate and potash. (See Table 3). The addition of the second 25 pounds per acre on Plot 4, compared with Plot 5, raised the cost per unit of production only slightly and made a material gain in return over cost of treatment.

The results of these tests seem to give abundant evidence to justify the general improvement of adapted permanent pasture lands. (See Fig. 3). The use of lime and phosphate at regular intervals on permanent pastures should become a definite and regular farm practice.

Where there is need for more pasture than results from the use of lime and minerals, as is likely to be the case on intensive dairy farms, the use of nitrogen in rather liberal amount appears to be well justified.

# INSOLUBLE COPPER COMPOUNDS AS VEGETABLE SPRAYS

J. D. WILSON AND H. A. RUNNELS

At present it seems likely that Bordeaux mixture will continue for some time to come to be the most commonly used, general-purpose material for spraying vegetables. However, the search for a substitute to be used on Bordeaux-sensitive plants, and even on others not so sensitive, is becoming more intensive each year. Even Bordeaux mixture, 50 years after its discovery, is still the subject of considerable investigation, carried on in an effort to find the most satisfactory formula for use on specific crops and for the control of specific diseases. The physiological reactions of plants to the application of Bordeaux mixture may be numerous and varied. Those which are evident from casual observation include such symptoms as hardening, thickening, and burning of leaf tissues; injury to flowers and growing points through tissue desiccation; stunting, particularly in dry weather, largely through an increase in transpiration; various growth abnormalities; and reductions in yield (1, 2, 3, 4). If leaf injury is severe enough, defoliation may result (4, 5). There are a number of copper compounds now on the market or available for experimental use which are not as active as Bordeaux mixture in altering the physiology of plants to which they are applied and, thus, are not as likely to cause the various forms of injury mentioned (6). These are usually spoken of as the insoluble copper compounds, although it is commonly recognized that they are not entirely insoluble, only relatively so. Accordingly, the term "insoluble" is used in the title and throughout this paper as a relative one only. The authors have applied a number of these materials to various vegetable crops during the last 5 years (2, 3, 7, 8, 9, 10) and some of the results obtained are the subject of this discussion.

The possibility of developing a satisfactory general-purpose treatment for cucumbers, one of the vegetables most sensitive to Bordeaux injury, has been under investigation for 10 years. The mixture of which such a treatment is composed should adhere to the foliage, act as a repellent to the cucumber

1. Wilson, J. D. and H. A. Runnels. 1933. Some detrimental effects of spraying tomatoes with Bordeaux mixture. Ohio Agr. Exp. Sta. Bimo. Bull. 18: 4-15.
2. Wilson, J. D. and H. A. Runnels. 1937. Five years of tomato spraying. Ohio Agr. Exp. Sta. Bimo. Bull. 22: 13-18.
3. Wilson, J. D. and H. A. Runnels. 1937. The effect of various spray materials on tomato transplants. Ohio Agr. Exp. Sta. Bimo. Bull. 22: 58-65.
4. Wilson, J. D. 1934. Some detrimental effects of Bordeaux mixture on plants. Proc. Ohio Veg. Grow. Assoc. 19: 33-39.
5. Wilson, J. D. and H. A. Runnels. 1931. Bordeaux mixture as a factor increasing drouth injury. Phytopath. 21: 729-738.
6. Wilson, J. D. and H. A. Runnels. 1935. The influence of various copper-containing fungicides on transpiration. Ohio Agr. Exp. Sta. Bimo. Bull. 20: 13-16.
7. Wilson, J. D. 1935. New treatments for cucumbers. Ohio Agr. Exp. Sta. Bimo. Bull. 20: 68-75.
8. Wilson, J. D. 1935. Bordeaux mixture substitutes on cucurbits. Proc. Ohio Veg. Grow. Assoc. 20: 8-14.
9. Wilson, J. D. 1936. The value of "insoluble" coppers in vegetable disease control. Proc. Ohio Veg. Grow. Assoc. 21: 99-104.
10. Wilson, J. D. and H. A. Runnels. 1937. The effectiveness of various copper-containing spray materials in vegetable disease control. The effect of seedbed treatments on tomato transplants. A test of copper fungicides, stickers, and spreaders on ginseng. Ohio Agr. Exp. Sta. Bull. 579, Fifty-fifth Ann. Rep., 36-38.

beetles which disseminate the bacterial wilt organism, not be injurious to the plants, and at the same time possess sufficient fungicidal merit to keep in check the various leaf spot diseases to which the cucumber is subject in Ohio. The senior author (7) has previously described a number of mixtures which gave good results in preliminary trials. Some of the most promising of these contained an insoluble copper, together with wheat flour and an insecticide, such as calcium arsenate. If the copper compound used contained 25 per cent of metallic copper (as several of them do), 1 part of the copper compound was usually mixed with 5 parts of flour and 1 part of calcium arsenate. This 1-5-1 formula was rather expensive and for this reason the flour, which is the cheapest constituent, was increased to 8 parts in later work. This 1-8-1 mixture is more costly than various other recommended treatments and there now seems to be some possibility of replacing half of the flour with a still cheaper material, such as talc or bentonite, at the risk, of course, of making the necessary ingredients of the four-way formula more difficult for the grower to assemble from the various sources of supply.

The basic dust formula used on cucurbits in this investigation consisted of 1 part of an insoluble copper compound, 8 parts of wheat flour, and 1 part of calcium arsenate. The relative amount of the copper compound used depended on the copper content in terms of metallic copper, and the basic formula presupposed a metallic copper content of 25 per cent. If this was greater, the amount used was a corresponding fraction of 1. It seems likely that nearly as good results may be obtained on cucurbits by replacing half of the flour with talc, a cheaper material. The basic spray formula contained the equivalent of 1 pound of metallic copper in 50 gallons of spray material. Again, in the case of a compound containing 25 per cent of metallic copper, the formula was a 4-4-50, which represents 4 pounds of the insoluble copper compound and 4 pounds of some material like wheat flour in 50 gallons of water. Formulas correspondingly weaker in the copper constituent were used on plants which are commonly sprayed with a Bordeaux mixture formula containing less than 4 pounds of copper sulfate in 50 gallons of material.

Data covering 5 years and limited to results obtained with mixtures containing one of the insoluble copper compounds, the commonly recommended gypsum-calcium arsenate mixture, Bordeaux mixture, and check plots (no treatment) are shown in Table 1. Numerous other combinations have been tested but are not included here, since most of them did not contain an insoluble copper compound. The data given in Table 1 refer, as is indicated, only to yields of pickling-size cucumbers. Supplementary data for others grown and harvested for seed are given in Table 2.

An inspection of these data shows that mixtures containing Coposil or the copper chlorides (basic copper chloride and Cupro-K) gave uniformly good results. Coposil scored somewhat higher in most instances. The other insolubles follow in varying order, and the standard gypsum-calcium arsenate treatment ranks about equal with them in most instances. Plots receiving Bordeaux mixture usually yielded the lowest of those treated and in some instances ranked even lower than the untreated checks. Vine measurements, taken in late July, usually showed that those plants which received Bordeaux mixture or no treatment were considerably smaller than those treated with most of the other mixtures listed in Tables 1 and 2.

TABLE 1.—Effect of Various Treatments on Cucumber Yields (Pickles) in Pounds per Plot at Wooster\*

Treatment	1933	1934	1935	1936	1937
	<i>Lb.</i>	<i>Lb.</i>	<i>Lb.</i>	<i>Lb.</i>	<i>Lb.</i>
Coposil + flour + calcium arsenate (1-8-1).....	112	147	91	87	164
Basic copper chloride + flour + calcium arsenate ( $\frac{3}{8}$ -8-1)....	87	129	88	100	166
Copper phosphate + flour + calcium arsenate ( $\frac{3}{8}$ -8-1).....		129		86	
Cuprous oxide + flour + calcium arsenate ( $\frac{1}{2}$ -8-1).....			71	89	
Gypsum + calcium arsenate (14-1).....	118	124	64	84	114
Basic copper sulfate + flour + calcium arsenate ( $\frac{1}{2}$ -8-1).....		120	66		
Bordeaux mixture + calcium arsenate (2-2-2-50).....	57	121	49	70	114
Check, untreated .....	50	78	53	63	57

\*Formulas given in this and succeeding tables are those used in 1937 and are not necessarily the same as those used in earlier experiments.

Some of the mixtures used in 1937 consisted only of the insoluble copper compounds and a diluent, and contained no insecticide, but plots treated with these consistently yielded less than others treated with the same ingredients plus calcium arsenate. This indicates that it is desirable to include an insecticide in the mixture and thus make it more effective against the cucumber beetle. Other results obtained in 1937 show that the replacement of part of the flour in a 1-8-1 formula with talc can be recommended only from the standpoint of cost reduction, since yields were decreased slightly when this substitution was made. Formulas which included no copper-containing compound, but only an insecticide and diluent, were decidedly inferior in most instances. Thus, it seems likely that a mixture which includes the fungicide, the diluent, and the insecticide is better than one with either the first or the last constituent left out.

TABLE 2.—Effect of Various Treatments on Yield of Seed Cucumbers in Pounds per Plot\*

Treatment	1935 Norwalk	1936 Norwalk	1936 Bowling Green	1937 Norwalk	1937 Bowling Green	1937 McGuffey
	<i>Lb.</i>	<i>Lb.</i>	<i>Lb.</i>	<i>Lb.</i>	<i>Lb.</i>	<i>Lb.</i>
Basic copper chloride + flour + calcium arsenate ( $\frac{3}{8}$ -8-1).....	300	206	185	288	457	966
Cupro-K + flour + calcium arsenate (1-8-1).....		212		281	401	863
Coposil + flour + calcium arsenate (1-8-1).....	346	220	165	322	385	
Copper Hydro 40 + flour + calcium arsenate (1-8-1).....				280	374	963
Cuprous oxide + flour + calcium arsenate ( $\frac{1}{2}$ -8-1).....		182	174			
Copper phosphate + flour + calcium arsenate ( $\frac{3}{8}$ -8-1).....		200	163			
Bordeaux mixture + calcium arsenate (2-2-2-50).....	279	108	167	236		822
Gypsum + calcium arsenate (14-1).....	203			250	351	
Check, untreated .....	100	113	159	170		492

\*The copper-containing compounds mentioned in the data of this paper were manufactured by the following companies: Basic copper chloride by the Grasselli Chemical Company, Cleveland; Cupro-K (copper oxychloride) and Cuprocide (cuprous oxide) by the Röhms & Haas Company, Philadelphia; Coposil (copper ammonium silicate) by the California Spray-Chemical Co., San Francisco; Copper Hydro 40 by the Chipman Chemical Co., Boundbrook, N. J.; Basicop (basic copper sulfate) by the Sherwin-Williams Co., Cleveland; copper phosphate by the Monsanto Chemical Co., St. Louis; and copper zeolite by the Nichols Copper Company, New York.

In Ohio the problems involved in treating muskmelons are similar to those encountered with cucumbers. Muskmelons, however, are more likely to be attacked by leaf spots, particularly the one caused by *Macrosporium cucumerinum* E. & E., than are cucumbers. The relative yields obtained in 3 different years when muskmelons were treated with a number of the insoluble copper compounds are shown in Table 3.

TABLE 3.—Effect of Various Treatments on Yield of Muskmelons in Pounds per Plot

Treatment	1934	1936	1937
	<i>Lb.</i>	<i>Lb.</i>	<i>Lb.</i>
Basic copper chloride + flour + calcium arsenate ( $\frac{1}{2}$ -8-1).....	151	584	690
Coposil + flour + calcium arsenate (1-8-1).....		447	670
Cupro-K + flour + calcium arsenate (1-8-1).....			663
Bordeaux mixture + calcium arsenate (2-2-2-50).....	85	439	579
Cuprous oxide + flour + calcium arsenate ( $\frac{1}{2}$ -8-1).....		410	
Copper phosphate + flour + calcium arsenate ( $\frac{1}{2}$ -8-1).....	141	370	
Basic copper sulfate + flour + calcium arsenate ( $\frac{1}{2}$ -8-1).....	138		
Check, untreated.....	100	262	463

The copper chlorides have given uniformly good results on this crop, and Coposil also ranks very well. Bordeaux mixture has given much better results on muskmelons than on cucumbers, probably because it usually gives good control of the rather late occurring leaf spot infections, which, as mentioned before, frequently appear in Ohio. However, a weak formula, such as a 2-2-50, must be used to avoid early stunting and later copper injury.

The consistently good results obtained with such low solubility copper compounds as copper oxychloride, basic copper chloride, and Coposil indicate that these, as well as possibly some of the others listed in Tables 1, 2, and 3, may be regarded as good substitutes for Bordeaux mixture and various other materials as treatments for cucumbers and muskmelons. The 1-8-1 mixture of the copper-containing compound (when the metallic copper content is 25 per cent), wheat flour, and calcium arsenate has given a good account of itself during the past 2 years and is now recommended to replace the more expensive 1-5-1 formula mentioned in a previous report (7). Mixtures containing these various copper compounds have given (with the exception of Bordeaux mixture, of course) better results when used as dusts than when added to water and applied as sprays. This has been found to be particularly true during the early growth stages of the plants, when they are especially susceptible to beetle injury and accordingly most liable to infection by bacterial wilt. In other words, the various materials seem to act as better beetle repellents when applied as dusts than when put on as liquids, possibly because of the heavier residue deposits obtained with the former method. There is some evidence, on the other hand, which indicates that the spray residues are more effective against leaf spot infections than are those of the dusts. For this reason it may be desirable to apply them as dusts to vining and then change over to the spray form in a basic 2-4-2-50 formula. In this formula 2 pounds of the copper-containing compound (proportionately less if the metallic copper content is over 25 per cent), 4 pounds of wheat flour, and 2 pounds of calcium arsenate are mixed together and then added to 50 gallons of water. The arsenate may be omitted or reduced in amount in late spray applications if desired, but its inclusion is probably well worth the extra cost.

The effects of various spray materials on the yield of staked tomatoes have been observed at Wooster during the past 6 years (2). In only two of several trials have plots sprayed with Bordeaux mixture given yields greater than those obtained from untreated checks. In both of these instances a leaf spot disease was serious enough to cause considerable defoliation, and the control afforded by Bordeaux mixture was great enough that plants treated with it were able to produce more fruit than those receiving no treatment. This statement also holds true for the use of treatments containing a number of the

insoluble copper compounds, as may be seen from the data of Table 4. However, the yields obtained from plants treated with these compounds have been greater than the yields from those receiving Bordeaux mixture in every instance in which comparisons have been made, that is, in five trials. On the basis of the experience of the authors to date, it may be stated that the application of copper-containing spray materials always fails to increase the yield of staked tomatoes in the absence of disease. Since a number of the mixtures used do not materially increase the rate of water loss from the plants (6), it seems likely that much of the decreased yield is caused by injury to the blossoms with subsequent failure of pollination, especially if the blossoms are in a particular stage of development at the time the spray material is applied. In other words, sprayed plants frequently set, and, therefore, bring to maturity, a smaller number of fruits than do untreated ones. This is particularly true for the first three or four clusters on plants treated with Bordeaux mixture.

TABLE 4.—Effect of Various Treatments on the Yield of Staked Tomatoes

Treatment	1933	1935	1936	1937	
				Wooster	Elyria
Check, untreated.....	<i>Lb.</i> 680	<i>Lb.</i> 630	<i>Lb.</i> 424	<i>Lb.</i> 672	<i>Lb.</i> 432
Cupro-K + flour (4-4-50).....		690	334	608	597
Coposil + flour (4-4-50).....	600		293		550
Cuprocide 54 (2-50).....					474
Bordeaux mixture (4-4-50).....	508	680	230	523	473

Experiments conducted during the past 4 years indicate not only that Bordeaux mixture is usually injurious to tomatoes, but also that the degree of injury varies with the formula used. In general, formulas in which the amount of lime exceeds the copper sulfate are more detrimental than formulas in which the reverse is true, within the usual limits of variation, of course (2). During the past season tomato plants treated with a 4-2-50 formula gave a 40 per cent greater yield than others receiving a 4-4-50 mixture. Severe injury frequently follows application of Bordeaux mixture to plants shortly before or after they are transplanted to the field (3). This is also true, but to a less extent, with some of the insoluble copper compounds. The longer the period elapsing between transplanting and the application of the first spray, granted there is no leaf spot infection, the smaller is the reduction in yield due to the treatment. This was illustrated during the past summer when plots receiving their first application of a 4-4-50 Bordeaux mixture at periods of 3, 6, and 9 weeks after transplanting yielded 373, 526, and 563 pounds, respectively.

That an increase in yield may be expected to result from spraying tomatoes when *Septoria* leaf spot is severe enough to cause a large amount of defoliation on untreated plants is indicated by the results obtained at Elyria in 1937. The first application of the various copper-containing materials listed was not made until the leaves were badly diseased nearly up to the second fruit cluster. Of the five insoluble copper compounds used, three gave better results than a 4-4-50 Bordeaux mixture and the other two were approximately equal to it. The maximum increase in yield from spraying at weekly intervals until about mid-September was about 38 per cent. This was obtained with Cupro-K, a proprietary copper oxychloride. Coposil ranked next with an increase of

nearly 27 per cent; whereas the increase obtained with Bordeaux mixture was a little less than 10 per cent. Thus, these results indicate that some, at least, of the insoluble copper compounds may and should be used as substitutes for Bordeaux mixture as tomato sprays.

Wilson and Newhall reported in 1930 (11) that a monohydrated copper sulfate-hydrated lime dust could be used as a substitute for Bordeaux mixture in the control of *Cercospora* and *Septoria* blights of celery. However, it was necessary to apply the dust under the very best of atmospheric conditions (while the plants were wet with dew and wind movement was at a minimum in late evening or very early morning) if the results were to equal those obtained with Bordeaux mixture applied in the usual manner. Coincident with the increasing availability on the market of the insoluble copper compounds, it was decided to compare their effectiveness with that of Bordeaux mixture in the control of these celery leaf blights. The results obtained in 1935 and 1937 are shown in Table 5.

TABLE 5.—Effect of Various Treatments on the Yield of Celery in Tons per Acre

Treatment	1935	1937
	<i>Tons</i>	<i>Tons</i>
Bordeaux mixture (4-4-50).....	10.28	4.44
Copper Hydro 40 + flour (4-4-50).....	10.04	4.13
Basic copper chloride + flour (2½-4-50).....	9.60	4.60
Coposil + flour (4-4-50).....	9.40	4.50
Cupro-K + flour (4-4-50).....	.....	4.24
Cuprocide 54 (2-50).....	9.28	4.02
Basic copper sulfate + flour (2-4-50).....	8.92	.....
Check, untreated.....	5.40	2.74

In 1935 late blight of celery (*Septoria apii* Rostrup) became prevalent at the time late celery was about half grown. None of the insolubles being tested gave as good results as Bordeaux mixture, although some of them approached it very closely. In 1937 the disease was present on the plants at the time they were set and did not entirely disappear at any time during the growth cycle of the host. Even under these severe conditions basic copper chloride and Coposil were equally as effective in disease control as Bordeaux mixture, and Cupro-K and Copper Hydro 40 were nearly as good. However, on this crop (which is not Bordeaux-sensitive but instead is usually benefited by its application, whether or not much disease is present) these materials cannot, because of the meager results available, be regarded as commercial substitutes for Bordeaux mixture, particularly in view of their greater cost.

The *Macrosporium* (*M. carotae* Ell.) and *Cercospora* (*C. apii carotae* Pass.) leaf blights of carrot are becoming increasingly common in Ohio, particularly in the northern portion. In tests conducted by the senior author in 1932 (12), Bordeaux mixture was found to give good control of these diseases. During the past two summers additional experiments have been conducted to compare the effectiveness of a number of the insoluble copper compounds with that of Bordeaux mixture in controlling these leaf spots. The results are given in Table 6.

11. Wilson, J. D. and A. G. Newhall. 1930. The control of celery blights. Ohio Agr. Exp. Sta. Bull. 461. 1-30.

12. Wilson, J. D. 1933. Spraying carrots for the control of leaf diseases. Ohio Agr. Exp. Sta. Bimo. Bull. 18: 2-4.

TABLE 6.—Effect of Various Treatments on Yield of Carrots in Tons per Acre

Treatment	1936	1937
	<i>Tons</i>	<i>Tons</i>
Cupro-K + flour (4-4-50) .....	15.8	13.95
Coposil + flour (4-4-50) .....		12.60
Copper Hydro 40 + flour (4-4-50) .....		12.45
Bordeaux mixture (4-4-50) .....	17.4	12.15
Basic copper chloride + flour (2½-4-50) .....	15.5	12.00
Cuprocide 54 (2-50) .....		8.40
Check, untreated .....	14.2	8.55

In 1936 none of the insolubles were as effective as Bordeaux mixture, but in 1937 three of the five tested gave better yields than Bordeaux, and a fourth was nearly as good. The data obtained to date must be regarded as inconclusive and the substitution on carrots of any of the low solubility copper compounds for Bordeaux mixture cannot be recommended until the completion of further trials, particularly when the difference in cost is also considered.

The authors have spent considerable time and effort trying to develop a reliable spray program for the control of *Alternaria* blight of ginseng (*A. panax* Whetzel) (13). Results accumulated to date indicate that the use of a 3-3-50 Bordeaux mixture applied at 14-day intervals from the time all of the plants are well through the ground until the seed heads are ready for harvest may be expected to give as good control as it is possible to obtain in combating this very serious and difficultly controllable disease. Since the disease may be expected to occur in a more or less severe outbreak each year and persistent effort must be made each year to control it, a ginseng planting is an excellent laboratory in which to compare the fungicidal virtues of new spray materials. Accordingly, tests involving most of the newly introduced insoluble copper compounds, as well as many others, have been conducted during each of the past three summers. The results obtained are given in Table 7. The data are given in terms of the percentage of plants showing disease lesions on the leaves, stems, or seed heads on a certain date each year. This procedure is necessary, since the crop is not harvested until 5 or 6 years after it is planted.

TABLE 7.—Percentage of Ginseng Plants Affected with *Alternaria* Blight About August 15 When Treated with Various Compounds

Treatment	1935	1936	1937
	<i>Pct.</i>	<i>Pct.</i>	<i>Pct.</i>
Bordeaux mixture (4-4-50) .....	2.5	12.6	11.8
Basic copper chloride + flour (2½-4-50) .....	46.0	54.3	13.0
Copper Zeolite (Z-O) + flour (4-4-50) .....			46.4
Copper Hydro 40 + flour (4-4-50) .....			55.6
Coposil + flour (4-4-50) .....	46.5	47.4	66.6
Cuprocide + flour (1½-4-50) .....	12.5	56.4	68.4
Copper phosphate + flour (2½-4-50) .....		82.0	
Basic copper sulfate + flour (2-4-50) .....	55.0		
Cupro-K + flour (4-4-50) .....			69.7
Check, untreated .....	100.0	100.0	100.0

It will be noted that none of the compounds tested have given results comparable to those obtained with Bordeaux mixture against *Alternaria* blight. Cuprocide did very well in 1935, but through an oversight, allowance was not

13. Runnels, H. A. and J. D. Wilson. 1933. Control of *Alternaria* blight of ginseng with Bordeaux mixture and injuries accompanying its use. Ohio Agr. Exp. Sta. Bull. 522, 1-16.

made for its very high content of metallic copper and, thus, an excessive amount was applied. None of the insoluble group gave satisfactory results in 1936. In 1937 basic copper chloride gave excellent control and, on the basis of seed heads matured, the plot treated with it was even superior to the one receiving Bordeaux mixture. However, none of the compounds tested to date have given results which would justify their use as substitutes for Bordeaux mixture in the control of *Alternaria* blight of ginseng, regardless of relative costs.

### SUMMARY

Bordeaux mixture is still the most commonly recommended and used material for spraying vegetables, but the search for a substitute on plants sensitive to it is becoming more active each year. Any material or materials which may be chosen to replace Bordeaux mixture will probably be found among the relatively insoluble copper compounds which are now being placed on the market by various chemical companies.

A number of these have been used on vegetables for the control of various diseases during the past 5 years, and some offer considerable promise. Two chlorides of copper (basic copper chloride and Cupro-K, a copper oxychloride) and Coposil (copper ammonium silicate) used in the basic dust formula (1-8-1) have given excellent results on cucumbers and muskmelons and are recommended on these crops in preference to Bordeaux mixture or copper-lime dust. The same materials used in the basic spray formula (4-4-50) increased the yield of tomatoes when disease was severe enough to be a retarding factor in fruit production and are recommended as substitutes for Bordeaux mixture on this crop, both in the seedbed and in the field. These same materials were found to compare favorably with Bordeaux mixture on carrots, celery, and ginseng but can hardly, as yet, be recommended to replace Bordeaux here because of their relatively greater cost.

A number of other insoluble copper compounds, such as Copper Hydro 40, Cuprocide 54, basic copper sulfate, and copper phosphate, have been tested also. Some of these gave good results in particular instances, but, on the basis of results so far obtained, none can be as highly recommended as substitutes for Bordeaux mixture as can basic copper chloride, Cupro-K, and Coposil.

Additional work is now planned to determine the best, and at the same time most economical, concentrations of some of the most promising insoluble copper compounds to use in the control of specific diseases.

# EFFECT OF GROWTH SUBSTANCES ON THE ROOTING OF WOODY ORNAMENTAL PLANTS

G. H. POESCH

During the past year the Division of Floriculture of the Ohio Agricultural Experiment Station has been experimenting in Columbus with the effect of various organic compounds commonly known as growth-promoting substances on the rooting of woody ornamental plants. Hitchcock and Zimmerman (1) report quicker and better rooting of *Ilex opaca* and *Taxus cuspidata* through the use of indoleacetic and naphthaleneacetic acid. Other workers found similar responses with various plants. The length of treatment and concentration of the solution used varied to such an extent that it was deemed necessary to conduct tests to determine the most effective treatment.

## MATERIALS AND METHODS

The following crystalline acids were used: indoleacetic and indolebutyric purchased from the Eastman Kodak Company and naphthaleneacetic purchased from R. H. Manske of the National Research Council. Indolebutyric acid constantly proved superior and for that reason was used more extensively.

Solutions of each growth substance were prepared by dissolving 1 gram of the material in 125 cubic centimeters of 95 per cent ethyl alcohol, then adding 125 cubic centimeters of distilled water to make a total volume of 250 cubic centimeters. This stock solution contains 4 milligrams of growth substance per cubic centimeter. Further dilutions were made from this stock solution. Examples of dilutions of this stock solution are given in Table 1.

TABLE 1.—Dilutions of Stock Solution of Growth-promoting Substances

Requirement	Amount of stock solution (4 mg. per 1 c. c.) per 1000 c. c.
1 mg. per 100 c. c. of water .....	C. c.
2 mg. per 100 c. c. of water .....	2½
3 mg. per 100 c. c. of water .....	5
4 mg. per 100 c. c. of water .....	7½
5 mg. per 100 c. c. of water .....	10
8 mg. per 100 c. c. of water .....	12½
10 mg. per 100 c. c. of water .....	20
	25

The desired solutions were placed in flat pans to a depth of ¾ inch. The cuttings were made as usual, bunched with the basal ends even, and placed in the solution for the desired length of time. The check cuttings were placed in distilled water for the same length of time. Usually the containers were placed in a lean-to greenhouse, in ample light but not direct sunlight. When the cuttings were removed from the solution they were placed directly into the rooting medium in the usual way without being washed with water. The usual care was given them during the rooting period.

1. Hitchcock, A. E. and P. W. Zimmerman. 1936. Effect of growth substances on the rooting response of cuttings. Contributions from Boyce Thompson Institute 8: No. 1, 63-79.

At the beginning of the tests the solutions were renewed for every set of cuttings. With sufficient trials it was found that the same solution could be used three to five times provided the solution was used within a week and evaporation had been kept down to a minimum.

## RESULTS

The results as compiled are given in Tables 2, 3, and 4. Table 2 shows the effect of the growth substances on cuttings of 57 woody ornamental plants that rooted and showed some response to the treatment. This table shows the most effective growth substance, the most effective concentration, and the effective range as determined in these tests. The range of concentrations used was  $\frac{1}{2}$ , 1, 2, 3, 5, 8, and 10 milligrams of the growth substance per 100 cubic centimeters of water. Some of the concentrations were omitted with some plants, but always an ample range was tried. The effective range of treatment as given applies to the specific conditions under which these tests were conducted and the nature of the cuttings at the time of the test. Varying conditions would undoubtedly alter to some extent the effective range. Other growth substances than the most effective are indicated where used.

The date the cuttings were taken as given in Table 2 applied to the particular set reported. Cuttings were often taken on other dates but the set that gave the most outstanding results is the one reported. The length of treatment was often varied for the different times of taking to fit the condition of the wood. The length of treatment given applied to the particular set reported. It is not meant to imply that this is always the best length of treatment for the concentration suggested.

Table 3 shows the effect of indolebutyric acid in relation to the time the cuttings were taken. The most effective concentration and length of treatment varied somewhat but the influence of the growth substance was of little importance in most cases.

Table 4 contains a list of 53 plants the cuttings of which did not respond to the treatments given. As indicated, treatment resulted in burning and death of the cuttings in some cases. The lack of reaction of some was due to unfavorable environmental conditions. Since all cuttings were handled in the same greenhouse, it was not always possible to maintain the most favorable temperature and humidity for all cuttings. The majority of the cuttings were in a satisfactory condition for a sufficiently long time to root. With some of the plants in the list, from 1 to 5 per cent of the cuttings rooted, but this was not considered significant.

## CONCLUSIONS

**Concentration and length of treatment.**—As would be expected, a weaker concentration and shorter periods of time have been found effective with the more succulent cuttings. An analysis of Table 2 shows that 1, 3, and 5 milligrams of growth substance per 100 cubic centimeters of water with treatments of 6 or 24 hours have been most effective. The exact concentration should be based on the maturity of the cuttings. A good propagator will soon be able to judge the general condition of his cuttings and treat accordingly. The more mature and harder the wood, the stronger the concentration or longer the length of the treatment should be.

**Increase in percentage of rooting and amount of roots. Decrease in time required.**—Table 2 will show for the most part that there has been an increase in the percentage of rooting during a given period. The saving in time of rooting with treatment will vary from a few days to as much as 2 or 3 weeks. It is doubtful if a few days' to a week's difference in the rooting period would be an important factor in the minds of most commercial nursery propagators. The more uniform and abundant root system on the treated cuttings has been striking in many cases.

**Rooting of different types.**—Table 2 will show comparatively few types of plants that are really difficult to root from softwood cuttings. In fact, these tests have given little indication that truly difficult rooting types have been greatly benefited by the treatments. Table 4 lists some of these difficult types as well as some others which have not responded. Lack of response may be due to unfavorable methods of treatment which have resulted in injury in some cases. Possibly the use of different growth substances or a modification of the concentration and length of treatment might result in a favorable response. Much more work needs to be done, especially on the more difficult rooting types.

**Relation of treatment to time of taking cuttings.**—One interesting point in Table 3 is the greater response resulting from the earliest treatment. Possibly the explanation of this lies in the greater content of the plant hormones in the cutting during the earlier stages of growth. Avery and his co-workers have shown that the maximum content of the plant hormones in the shoot occurs just before the most rapid expansion of the current season's growth. Following this, there is a gradual decrease during the summer. Therefore it might be assumed that the greatest response to the growth substances would occur at this period of the most rapid expansion.

**Relation of synthetic growth substances and trade name materials.**—From the work done at the Ohio State University there seems to be no significant difference, in the results secured, between the crystals of the acids and the trade-marked materials. The choice might, therefore, depend upon the propagator's desire for a cheaper material or more convenience in the preparation of the solutions.

## PRECAUTIONS

The present status of the work would indicate that the use of synthetic growth substances is not a cure-all for all the difficulties involved in the propagation of plants by cuttings. The materials should be used with caution and directions, wherever possible, followed carefully. Much more experimental work must be done before all the questions concerning the use of these materials can be answered. The commercial propagator should proceed accordingly with their use.

Variations are bound to occur following the use of these materials by individual propagators. Atmospheric and cultural factors will vary, and this will lead to different results. Such factors as the amount of leaves on the cutting, the amount of light preceding the time of taking the cuttings, and the nitrogen content will influence the reaction to treatments.

It should be understood by commercial propagators that because cuttings of a certain plant respond to a treatment of indolebutyric acid is no assurance that similar cuttings will respond to a corresponding treatment of indoleacetic acid. Variations will occur and must be expected.

TABLE 2.—Effect of Synthetic Growth Substances on the Rooting of Cuttings of Woody Ornamental Plants

Plant	Num- ber of cut- tings per plot	Growth substances				Others used in test	Date cuttings taken	Length of treatment	Days for rooting	Percentage rooted	
		Most effective		Range	Check					Treated	
		Material	Concen- tration								
				Milligrams per 100 c. c. of H <sub>2</sub> O							
<i>Acanthopanax pentaphylo</i>	10	Indolebutyric acid	10	.....	Indoleacetic	Aug. 19	Hr.	55	50	80	
<i>Acer palmatum</i>	30	Indolebutyric	5	.....	.....	June 25	20	42	0	20	
<i>Amelopsis tricuspidata</i>	20	Indolebutyric	3	1-3	.....	Aug. 4	24	20	90	90	
<i>Berberis thunbergii pluriflora erecta</i>	25	Indolebutyric	1	1-3	.....	July 7	6	47	32	47	
<i>Celastrus scandens</i>	25	Indolebutyric	3	1-3	.....	July 7	6	50	0	100	
<i>Cornus sanguinea</i>	25	Indolebutyric	3	3-5	.....	June 29	12	21	44	68	
<i>Euonymus alatus</i>	25	Indolebutyric	1	1-3	.....	June 24	18	41	44	76	
<i>Euonymus europaeus</i>	10	Indolebutyric	10	.....	Indoleacetic	Aug. 12	21	43	0	80	
<i>Euonymus pateris</i>	25	Indolebutyric	1	1/2-3	.....	July 24	24	36	16	100	
<i>Euonymus radicans</i>	20	Indolebutyric	10	.....	Indoleacetic	Aug. 19	21	36	65	80	
<i>Euonymus radicans coloratus</i>	30	Indolebutyric	3	1-5	.....	June 28	6	21	100	100	
<i>Euonymus radicans minimus</i>	20	Indolebutyric	10	5-10	Indoleacetic	Aug. 12	24	43	87	100	
<i>Euonymus radicans vegetus</i>	30	Indolebutyric	5	.....	Indoleacetic	Aug. 18	21	36	65	80	
<i>Forsthia suspensa</i>	25	Indolebutyric	3	1-5	.....	June 22	6	27	40	100	
<i>Hedera helix</i>	25	Indolebutyric	5	1-8	.....	July 5	4	15	96	100	
<i>Hibiscus syriacus</i>	25	Indolebutyric	3	1-8	.....	July 5	6	36	52	100	
<i>Hydrangea ptilularis</i>	25	Indolebutyric	3	3-8	.....	July 28	22	60	0	16	
<i>Hydrangea quercifolia</i>	10	Indolebutyric	3	1-3	.....	July 8	10	50	0	40	
<i>Ilex crenata</i>	15	Indolebutyric	3	1-3	.....	Aug. 10	24	51	0	53	
<i>Ilex glabra</i>	25	Indolebutyric	5	1-5	Indoleacetic Naphthalene- acetic	July 8	24	31	4	96	
<i>Ilex opaca</i>	15	Indolebutyric	3	3-5	.....	June 24	24	43	0	53	
<i>Juniperus horizontalis plumosa</i>	25	Indolebutyric	2	2-5	.....	Feb. 4	18	20	64	72	
<i>Kolkwitzia amabilis</i>	25	Indolebutyric	8	5-8	.....	June 30	10	40	4	92	
<i>Ligustrum obtusum</i>	25	Indolebutyric	5	1-8	.....	July 5	6	32	72	76	
<i>Ligustrum ibola regelianum</i>	30	Indolebutyric	5	1-5	.....	June 24	6	46	87	93	
<i>Ligustrum vulgare</i>	25	Indolebutyric	3	3-10	.....	July 9	5	32	16	64	
<i>Lonicera korolkovi</i>	10	Indolebutyric	10	5-10	Indolebutyric	Nov. 14	40	53	50	80	
<i>Pachysandra terminalis</i>	25	Indolebutyric	3	1-5	.....	June 22	6	28	60	100	

TABLE 2.—Effect of Synthetic Growth Substances on the Rooting of Cuttings of Woody Ornamental Plants—Concluded

Plant	Num-ber of cuttings per plot	Growth substances				Date cuttings taken	Length of treatment	Days for rooting	Percentage rooted	
		Most effective		Material	Others used in test				Check	Treated
		Concen-tration	Range							
<i>Philadelphus coronarius</i> .....	25	5	3-8	.....	.....	July 6	Hr.	14	8	56
<i>Physocarpus opulifolius</i> .....	10	5	5-10	.....	Indoleacetic	Nov. 14	20	53	80	90
<i>Prunus tomentosum</i> .....	25	1	1-3	.....	.....	June 24	6	27	4	84
<i>Pyracantha coccinea lauciflora</i> .....	20	5	5-10	.....	Indolebutyric	Nov. 11	24	48	60	75
<i>Rhodotyphus kerritoides</i> .....	25	1	1-2	.....	.....	July 24	24	30	0	76
<i>Ribes alpinum</i> .....	25	8	5-8	.....	.....	June 29	12	35	0	44
<i>Rosa Max Graf</i> .....	30	5	1-5	.....	.....	June 26	12 1/2	24	3	7
<i>Salix discolor</i> .....	25	5	1-5	.....	.....	June 29	6	21	36	72
<i>Salix incana</i> .....	25	1	1-3	.....	.....	June 30	6	20	60	96
<i>Stephanandra flexuosa</i> .....	25	3	1-5	.....	.....	July 1	6	19	88	88
<i>Syringa hybrid</i> , Pres. Grey.....	25	8	1-8	.....	.....	June 20	3	47	24	32
<i>Syringa meyeri</i> .....	25	5	1-5	.....	.....	July 9	6	56	12	44
<i>Syringa villosa</i> .....	25	5	1-5	.....	.....	June 20	6	47	80	72
<i>Taxus baccata washingtoni</i> .....	10	5	1-20	.....	.....	Jan. 16	12	93	70	80
<i>Taxus cuspidata</i> .....	20	5	1-5	.....	.....	Jan. 16	12	92	85	100
<i>Taxus cuspidata</i> .....	30	5	1-5	.....	.....	June 22	6	97	77	90
<i>Taxus cuspidata nana</i> .....	10	5	1-5	.....	.....	Jan. 16	12	93	30	50
<i>Taxus media hicksi</i> .....	30	5	1-5	.....	.....	Jan. 16	12	93	30	80
<i>Taxus media hicksi</i> .....	10	5	1-5	.....	.....	June 22	6	98	43	40
<i>Viburnum americana</i> .....	25	1	1/2-2	.....	Naphthalene-acetic	Aug. 26	24	32	88	92
<i>Viburnum carlesii</i> .....	25	3	1-5	.....	.....	June 22	6	16	15	64
<i>Viburnum dentatum</i> .....	25	10	5-10	.....	.....	June 25	16	25	56	96
<i>Viburnum dentatum</i> .....	20	1	1-3	.....	Indoleacetic	Aug. 25	24	31	30	95
<i>Viburnum lantana</i> .....	25	1	1-3	.....	.....	July 1	6	19	88	88
<i>Viburnum opulus</i> .....	25	1	1-3	.....	.....	June 24	6	21	76	100
<i>Viburnum opulus nana</i> .....	25	3	1-5	.....	.....	July 9	5	31	96	100
<i>Viburnum sieboldi</i> .....	25	1	1-3	.....	.....	July 23	24	31	48	84
<i>Vinca minor</i> .....	25	2	1/2-4	.....	.....	Aug. 5	24	19	84	100
<i>Vitex negundo incisa</i> .....	25	5	1/2-3	.....	.....	July 30	24	22	4	64
<i>Weigela hybrida</i> .....	20	5	5-8	.....	Indoleacetic	Aug. 25	24	31	30	95
<i>Weigela rosea</i> .....	25	5	1-8	.....	.....	June 29	12	20	0	72

TABLE 3.—Effect of Growth Substances in Relation to Time of Taking Cuttings

Plant	Num- ber of cut- tings per plot	Growth substance					Days for rooting	Percentage rooted	
		Material	Most effective		Date cuttings taken	Length of treatment		Check	Treated
			Concen- tration	Range					
				Milligrams per 100 c. c. of H <sub>2</sub> O					
<i>Viburnum opulus</i> .....	25	Indolebutyric acid	1	1-3	June 24	1/1r.	21	76	100
<i>Viburnum opulus</i> .....	25	Indolebutyric acid	1	1-3	June 28	6	22	100	100
<i>Viburnum opulus</i> .....	25	Indolebutyric acid	1	1-3	July 6	6	14	96	96
<i>Viburnum opulus</i> .....	25	Indolebutyric acid	1	1-3	July 12	6	28	76	84
<i>Viburnum opulus</i> .....	25	Indolebutyric acid	1/2	1/4-2	July 20	24	20	68	80
<i>Viburnum opulus</i> .....	25	Indolebutyric acid	1	1/2-2	July 27	24	27	56	60
<i>Viburnum opulus</i> .....	20	Indolebutyric acid	1	.....	Aug. 3	24	24	90	80

Commercial propagators must decide for themselves whether the benefits derived from the treatments are important enough to warrant the practice. They must decide whether the saving of a few days or a week is important, and whether the production of a few more roots will lead to more rapid growth and better mature plants. Little information is available at present on what effect the growth substances have on the growth and final development of the plant.

**TABLE 4.—Plants That Did Not Respond to Treatments  
with Growth Substances**

Name	Name
<i>Abelia grandiflora</i>	<i>Halesia tetraptera</i>
<i>Acer campestre</i>	<i>Ilex crenata latifolia</i>
<i>Arctostaphylos uva-ursi</i>	<i>Juniperus chinensis pfitzeriana</i>
<i>Aronia arbutifolia</i>	<i>Juniperus excelsa stricta</i>
<i>Azalea dahuricum mucronulatum</i>	<i>Juniperus sabina Von Ehron</i>
<i>Benzoin aestivale</i>	<i>Juniperus virginiana</i>
<i>Calycanthus floridus</i>	<i>Juniperus virginiana globosa</i>
<i>Carpinus betulus</i>	<i>Juniperus virginiana lictelceri</i>
<i>Chamaecyparis obtusa</i>	<i>Larix decidua</i>
<i>Chamaecyparis pisifera aurea</i>	<i>Magnolia kobus</i>
<i>Cornus florida rubra</i>	<i>Mahoeberberis neuberti latifolia</i>
<i>Cornus mas</i>	<i>Malus arnoldiana</i>
<i>Cotoncaster adpressa</i>	<i>Malus purpurea</i>
<i>Cotoneaster apiculata</i>	<i>Myrica caroliniensis</i>
<i>Cotoneaster dielsiana</i>	<i>Pinus densiflora umbraculifera</i>
<i>Cotoneaster divaricata</i>	<i>Pinus strobus</i>
<i>Cotoneaster foveolata</i>	<i>Prunus pissardi</i>
<i>Cotoneaster horizontalis</i>	<i>Prunus subhirtella pendula</i>
<i>Cotoneaster moupinensis</i>	<i>Quercus robur fastigiata</i>
<i>Cotoneaster simonsi</i>	<i>Rhamnus frangula</i>
<i>Cotoneaster zabeli</i>	<i>Taxus baccata repandens</i>
<i>Crataegus cordata</i>	<i>Taxus cuspidata capitata</i>
<i>Cydonia japonica</i>	<i>Thuja orientalis aurea nana</i>
<i>Daphne cneorum</i>	<i>Ulmus pumila</i>
<i>Deutzia lemoinei</i>	<i>Viburnum lentago</i>
<i>Elaeagnus pungens reflexa</i>	<i>Viburnum rhytidolphyllum</i>
<i>Exochorda grandiflora</i>	

# **SOME RELATIONSHIPS BETWEEN THE BLOOM PERIOD AND SPRAYING DATES**

**C. W. ELLENWOOD**

The relationship between phenological conditions and such fruit growing problems as spraying and pollination is generally recognized by fruit growers.

The data presented here taken from phenological and spray records at the Station show a 10-year average bloom period for 12 of the standard apple varieties and also the dates within which the prebloom sprays were applied during the same years.

The 12 varieties included in Table 1 comprise early, midseason, and late blooming sorts. The data used in preparing these tables were accumulated from records at Wooster and the dates indicated may not correspond with those in other parts of the State. There is reason to suppose, however, that the length of the blooming season in other sections of the State would be similar to that shown in Table 1.

## **EXPLANATION OF TERMS**

In Table 1 the blooming seasons are divided into three periods, first bloom, beginning of full bloom, and end of full bloom. As used here, first bloom is the date upon which the first petals are completely open. The beginning of the full bloom stage is the date when all of the central flowers in the bud clusters and the maximum number of laterals are open. The end of the full bloom period is the time when the petals begin to fall in profusion. It is realized that it is difficult to make a classification of this nature, since these dates are not always clearly defined.

## **INFLUENCE OF SEASONAL GROWING CONDITIONS ON TIMING SPRAYS**

Generally the most important period for applying sprays to control apple scab is from what is designated as the prepink development of the fruit buds to the early bloom stages. In some years the period of primary scab infection may extend over to the petal-fall period or a little later.

In Table 2 are presented the dates when the first scab spray was applied and the dates when the petal-fall spray was started at Wooster for a 10-year period. It will be noted that the average length of this period was 28 days. The shortest space between these two stages of development was 18 days and the longest, 41 days. The 18-day period occurred in 1936 and is the shortest time recorded since records of this nature have been kept at the Station. It is worth noting that in 1924, 49 days elapsed from the time the first prebloom spray was applied until the beginning of the petal fall and that in 1923, 48 days elapsed.

Most of the spraying for the prevention of apple scab is done in a somewhat shorter period than the space from prepink to petal fall. Spraying is usually suspended from the early bloom stage or earlier until the petals are well off the trees.

TABLE 1.—Apple Blooming Dates  
Bloom period at Wooster, 1928-1937

Variety	Av. date of bloom for 10-year period			Earliest bloom during 10 years				Latest bloom during 10 years				Shortest period of bloom	Longest period of bloom	Av. length of bloom period
	First bloom	Full bloom		First bloom	Full bloom		First bloom	Full bloom						
		Beginning	End		Beginning	End		Beginning	End					
Baldwin.....	May 2	May 7	May 10	Apr. 22	Apr. 28	Apr. 30	May 8	May 13	May 16	5	14	9		
Cortland.....	May 3	May 7	May 9	Apr. 22	Apr. 28	Apr. 30	May 8	May 13	May 16	4	13	7		
Delicious.....	May 2	May 8	May 10	Apr. 21	Apr. 27	Apr. 29	May 8	May 15	May 18	4	11	9		
Golden Delicious.....	May 5	May 9	May 12	Apr. 22	Apr. 30	May 2	May 10	May 16	May 19	4	11	8		
Grimes.....	May 3	May 7	May 10	Apr. 21	Apr. 26	Apr. 28	May 9	May 14	May 16	4	11	8		
Jonathan.....	May 2	May 8	May 10	Apr. 21	Apr. 28	Apr. 30	May 8	May 13	May 18	5	14	9		
McIntosh.....	May 2	May 7	May 9	Apr. 21	Apr. 24	Apr. 27	May 6	May 12	May 14	4	12	8		
Northern Spy.....	May 6	May 10	May 13	Apr. 25	Apr. 30	May 3	May 12	May 18	May 20	5	12	8		
Oldenburg.....	Apr. 29	May 5	May 8	Apr. 16	Apr. 24	Apr. 26	May 4	May 11	May 13	6	14	10		
Rome Beauty.....	May 5	May 10	May 13	Apr. 25	May 1	May 4	May 12	May 18	May 20	4	14	9		
Stayman Winesap.....	May 2	May 8	May 11	Apr. 21	Apr. 27	Apr. 29	May 8	May 14	May 17	5	12	10		
Yellow Transparent.....	May 3	May 8	May 10	Apr. 22	Apr. 28	May 1	May 10	May 14	May 17	4	11	8		
Average for 12 varieties.....	May 3	May 8	May 11	.....	.....	.....	.....	.....	.....	5	12	9		

The application of spray solution during the early days of the blooming period is by no means universal among Ohio growers, but the practice is more common than it was a few years ago. Some years it is considered a necessary part of the spray schedule. The so-called blossom spray is applied in the early part of the bloom period. The time of application corresponds closely to the period intervening between the date of first bloom and that of the beginning of full bloom. For the 12 varieties the 10-year average length of this period was 6 days. For the 10 years covered by the records presented here the average length of time from the application of the first prebloom or scab spray until the beginning of the full bloom period for the 12 varieties was 20 days. The shortest period was 11 and the longest, 30 days.

**TABLE 2.—Dates of Spraying Apple Trees**  
First prebloom and petal-fall sprays, Wooster, 1928-1937

Year	Date first prebloom spray began	Date of beginning of full bloom	Date petal-fall spray began	Number of days from first prebloom to petal fall
1928	Apr. 12	May 13	May 22	41
1929	Apr. 9	Apr. 28	May 6	28
1930	Apr. 14	Apr. 30	May 8	25
1931	Apr. 20	May 10	May 21	32
1932	Apr. 28	May 9	May 19	22
1933	Apr. 20	May 9	May 17	28
1934	Apr. 25	May 7	May 15	21
1935	Apr. 18	May 10	May 20	33
1936	Apr. 28	May 9	May 15	18
1937	Apr. 20	May 14	May 22	33
<b>Average.</b>	Apr. 19	May 8	May 17	28

Since complete and continuous coverage is an essential part of any spray program, particularly early in the year, it will be seen that the number of applications required for protection depends very largely upon the length of time elapsing from prepink to the bloom period. In some years two sprays are sufficient to give good coverage. In the seasons of more prolonged development five applications may be required. A full discussion of spray schedules may be found in Bulletin 591<sup>1</sup>. The data given in Tables 1 and 2 will give the grower some indication of the time limits within which he may expect to have to make the early season spray applications.

#### RELATION OF BLOOM PERIOD TO POLLINATION

Pollination may occur any time after the petals have opened, that is, between the dates designated (Table 1) as first bloom and the end of full bloom, or somewhat later, for it must be noted that frequently some lateral buds open after most of the petals have fallen. The optimum period for pollination is within the time here designated as full bloom. This is nearly always a much shorter period than from first bloom to the beginning of full bloom.

<sup>1</sup>Bulletin 591 is a joint publication of the Ohio Agricultural Experiment Station and the Agricultural Extension Service.

Among the varieties listed in Table 1 Oldenburg was the earliest to open blossoms. Rome Beauty, Northern Spy, and Golden Delicious are rated as late blooming varieties. Between the earliest and latest varieties there was a difference of an average of 8 days in the appearance of first bloom for this 10-year period. There was a differential of 6 days between the earliest and latest variety in the period designated as the beginning of full bloom and there was the same length of time between the early and late varieties at the end of the bloom. Since the varietal difference tends to be less between the beginning and end of full bloom than between first bloom and the beginning of full bloom, there is considerable overlapping of the blooming periods in most varieties.

# SOME LESS WELL-KNOWN ROCK PLANTS IN OHIO

F. H. BALLOU

In the estimation of rock gardeners of considerable experience, the more desirable kinds of plants for their use are those that are content to bloom and perpetuate themselves wholly within the soil pockets and crevices between the rocks to which they have been assigned. Widely spreading plants may serve acceptably where ground covers or screens for hiding unsightly objects are desirable, but they are not suitable for use in rock gardens, where the rocks themselves, fully weathered and naturally arranged, should contribute largely to the interest and attractiveness of the plantings.

The rock and alpine plants named in Table 1 are more or less familiar to most botanists and floriculturists, but are not commonly grown or known by average nurserymen of Ohio who depend principally on field culture for production of stock usually sold for use in rock gardens. The list submitted embraces some of the more diminutive species of the genera represented, and therefore these plants are well suited for use in small, as well as large, planting projects.

TABLE 1.—Some Less Well-known Rock and Alpine Plants

Botanical name	Common name	Height
For sunny exposures		
<i>Achillea aurea</i> ; <i>A. nana</i> ; <i>A. umbellata</i> .....	Yarrow	3- 6
<i>Actinea herbacea</i> .....	Lakeside Daisy	8-10
<i>Alyssum montana</i> ; <i>A. spinosum</i> .....	Madwort	4- 6
<i>Antennaria dioica</i> ; <i>A. rhodantha</i> .....	Cat's-ear	1- 2
<i>Astilbe simplicifolia</i> .....	Spirea	6- 8
<i>Chrysopsis villosa</i> .....	Chrysopsis	8-10
<i>Coronilla cappadocica</i> .....	Crown Vetch	4- 6
<i>Draba fladriensis</i> ; <i>D. repens</i> .....	Whitlowgrass	2- 3
<i>Edithanthus dubautius</i> .....	Wahlenbergia	2- 3
<i>Erodium chamaedryoides</i> .....	Heronbill	2- 3
<i>Geranium sanguineum lancastriense</i> .....	Cranesbill	3- 4
<i>Geum Borissi</i> .....	Avens	6- 8
<i>Globularia nana</i> ; <i>G. bellidifolia</i> .....	Globedaisy	1- 3
<i>Gypsophila fratenis</i> .....	Baby's Breath, dwarf	2- 3
<i>Haltantheum speciosum</i> .....	Rock Rose	6- 8
<i>Hypericum reptans</i> ; <i>H. cors</i> .....	St. Johnswort	3- 6
<i>Iberis revertens</i> .....	Candytuft, dwarf	1- 3
<i>Linaria acutiriloba</i> .....	Toad flax	1- 2
<i>Lotus corniculatus</i> .....	Birdsfoot Trefoil	4- 6
<i>Melampodium cinereum</i> .....	Colorado Rock Daisy	6- 8
<i>Penstemon humilis</i> .....	Beard-tongue	6-12
<i>Solidago Cutleri</i> .....	Goldenrod	3- 4
<i>Sieversia ciliata</i> .....	Geum	4- 6
<i>Stachys corsica</i> .....	Woundwort, dwarf	1- 2
For partly shaded situations		
<i>Aquilegia flabellata nana alba</i> .....	Columbine	6- 8
<i>Corydalis cheilanthisifolia</i> .....	Fumitory	6- 8
<i>Epimedium</i> in varieties.....	Barrenwort	6- 8
<i>Mentha requienii</i> .....	Mint	½- 1
<i>Saxifraga granulata</i> ; <i>S. marginata</i> ; <i>S. trifurcata</i> .....	Rockfoil	6- 8

# INDEX NUMBERS OF PRODUCTION, PRICES, AND INCOME

J. I. FALCONER

In spite of the decline in prices at the end of the year, the cash income received by Ohio farmers from the sale of farm products for the year 1937 exceeded that of 1936 by 10 per cent. At the end of the year prices received by farmers were 11 per cent below the prices received at the beginning of the year and 18 per cent below those received in July. Prices paid by farmers for supplies purchased had declined by 4 per cent since July.

## Trend of Ohio Prices and Wages, 1910-1914=100

	Wholesale prices, all commodities U. S.	Weekly earnings N. Y. State factory workers	Prices paid by farmers	Farm products prices U. S.	Ohio farm wages	Ohio farm real estate	Ohio farm products prices	Ohio cash income from sales
1913.....	102		101	101	104	100	105	101
1914.....	99	100	100	101	102	102	105	108
1915.....	102	101	105	98	103	107	106	111
1916.....	125	114	124	118	113	113	121	121
1917.....	172	129	149	175	140	119	182	199
1918.....	192	160	176	202	175	131	203	240
1919.....	202	185	202	213	204	135	218	266
1920.....	225	222	201	211	236	159	212	226
1921.....	142	203	152	125	164	134	132	130
1922.....	141	197	149	132	145	124	127	130
1923.....	147	214	152	142	166	122	134	144
1924.....	143	218	152	143	165	118	133	146
1925.....	151	223	157	156	165	110	159	174
1926.....	146	229	155	145	170	105	155	177
1927.....	139	231	153	139	173	99	147	165
1928.....	141	232	155	149	169	96	154	156
1929.....	139	236	153	146	169	94	151	165
1930.....	126	226	145	126	154	90	128	137
1931.....	107	207	124	87	120	82	89	100
1932.....	95	178	107	65	92	70	63	73
1933.....	96	171	109	70	74	59	69	85
1934.....	110	182	123	90	77	63	85	98
1935.....	117	191	125	108	87	66	110	127
1936.....	118	199	124	114	100	74	118	147
1937.....	126		131	121	118	77	128	161
1936								
July.....	118	198	123	115	105		121	189
August.....	119	202	126	124			131	183
September.....	119	198	127	124			127	169
October.....	119	202	127	121	108		124	164
November.....	120	201	127	120			123	158
December.....	123	211	128	126			127	160
1937								
January.....	125	209	130	131	104		128	151
February.....	126	211	132	127			127	141
March.....	128	218	132	128		77	129	157
April.....	128	219	134	130	118		134	170
May.....	127	219	134	128			135	164
June.....	127	220	134	124			134	162
July.....	128	218	133	125	123		138	191
August.....	128	220	132	123			135	171
September.....	128	215	130	118			129	164
October.....	125	214	128	112	127		123	156
November.....	122	205	128	107			116	156
December.....	119		128	104			114	142





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No. 192

## Ohio Agricultural Experiment Station

WOOSTER, OHIO, U. S. A.



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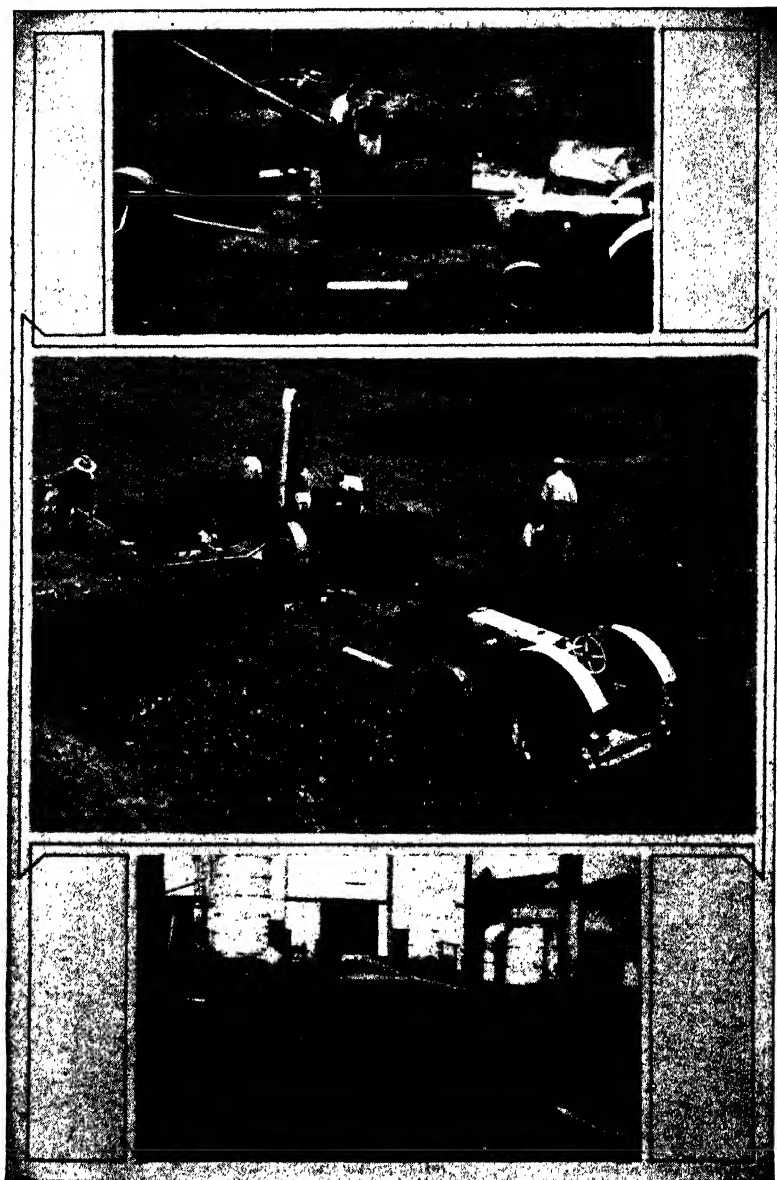
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### Free Bulletin

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*Edmund Secrest*  
Director



**Fig. 1.—Stages in the filling of temporary silos**

- Upper—**Starting to fill silo No. 1 with untreated second-cutting alfalfa
- Middle—**Silo No. 1 is receiving final tramping. Silo No. 3 is being filled with acid-treated second-cutting alfalfa. Note method of applying acid.
- Lower—**Silos No. 1 and 3 have been capped. Silo No. 2 was filled the next day with molasses-treated second-cutting alfalfa.

# A TRIAL WITH TEMPORARY SILOS<sup>1</sup>

W. E. KRAUSS, C. C. HAYDEN, A. E. PERKINS, AND R. G. WASHBURN

Controlled experiments and actual experience have shown that temporary silos can be used satisfactorily for the storage of corn silage. Practically nothing has been recorded relative to the suitability of temporary silos for legume silage, particularly that prepared by the acid or molasses treatment method.

Since legume silage would often be made during the early or middle part of summer, the question of the keeping qualities of silage in temporary silos during hot weather seemed pertinent. A trial was planned, therefore, to study the physical problems involved in storing legumes in temporary silos, and to obtain data on the quality of the silage.

## BUILDING AND FILLING THE SILOS

The paper-lined snow-fence type of temporary silo was selected as representative. The land set aside for the silos was slightly sloping and heavily sodded. In order to provide a level, firm base for the rings of fencing, three 8-inch-wide circular bands were cut in the sod to an absolutely level plane. These circles were 8 feet in diameter from inner edge to inner edge. Rings were made of 25-foot strips of fencing set up on these leveled bases and lined with sheets of 4-foot by 10-foot Treated Sisalkraft.

On July 21, 1937, a small section of a field of alfalfa, one-third to one-half in bloom, was cut for the second time. As soon after cutting as possible the green alfalfa was collected, hauled to the cutter, and blown into temporary silos No. 1 and No. 2 (see Fig. 1). The day was hot but a strong breeze was blowing, and conditions were ideal for rapid drying.

Silo No. 1 was filled to above the top by mounding with 4300 pounds of green alfalfa. No water was added nor was any preservative used. This silo was to serve as an untreated control. After the green material had been tramped to below the upper edge of the fencing, the top was entirely covered with Treated Sisalkraft, generously lapped and tucked in around the edges. About 300 pounds of dirt and sod were thrown over the paper, which was further weighted by watering with a hose. Two days later approximately 300 pounds of spoiled silage were thrown on top of the wet dirt.

Silo No. 3 was filled during the early afternoon of July 21 to within 6 inches of the top. A second ring of fence was then tied in place with binder twine and lined with paper. Filling was continued until the top was well mounded. After the silage was tramped flush with the top, this silo was capped with Treated Sisalkraft which was stretched over the top and allowed to hang down the sides, where it was tied with a belt of binder twine. About 1000 pounds of chopped green material and old silage were thrown on top of the paper.

As the chopped alfalfa was blown into this silo it was sprayed with a 2N mixture of hydrochloric and sulfuric acids (4:1) at the rate of 15 gallons per ton.

<sup>1</sup>The materials needed for this test were furnished by The Sisalkraft Co., Chicago, Illinois, to whom the authors are indebted not only for materials but also for technical advice and assistance.

Silo No. 2 was filled on the next day (also a good drying day) with freshly cut alfalfa to within 6 inches of the top. A second ring of fence was then tied in place with binder twine and lined with paper. Filling was continued until the silage was within 6 inches of the top, and a third ring of fence was then set in place. This third ring was filled to a height of only about 12 inches so that after settling the silo would be filled flush with the top of the second ring of fencing. Topping of this silo was done in much the same way as that of No. 1, except that chopped green material and old decayed silage were used for weighting.

As the green material was blown into this silo it was sprayed with a dilute molasses-water solution at the rate of 40 pounds of molasses per ton.

During the filling operations the cut material was thoroughly tramped, but even with considerable precaution silo No. 3 was leaning by the time it was full. This may have been due to the angle at which the cut material was delivered or to improper placing of the second tier of fence on the first tier. This leaning resulted in strain on the paper, which crinkled and cracked later in numerous places.

It was also noted that wherever the mineral acid mixture touched the paper lining on the outside surface, the outer sheet split. Such places were mended with adhesive tape at the time, but later inspection showed that these original breaks had enlarged to such an extent that air could easily get through. Some of the paper lining used in these silos was dipped in the mineral acid mixture used in silo No. 3. After a very short time the paper had lost its tenacity and could easily be torn apart.

### OPENING THE SILOS

For demonstration purposes silo No. 1 (untreated) was partially opened on August 13, 1937. The paper cap was intact and there was no spoilage. The condition of the silage was excellent. It had plenty of green color and tasted and smelled like dry hay. The silo was recapped at the end of the day and reopened on October 4. At this time there was little spoilage underneath the paper but considerable spoilage around the edge. This edge spoilage extended down to the bottom, a condition shown to exist as the silage was fed out. The temperature 4 inches below the surface of the first good silage was 107° F.

Silo No. 3 (molasses-treated) was opened on October 16, 1937. The paper cap was completely disintegrated. The silage was dark brown and very wet, and there was considerable spoilage on top as well as around the edge. The temperature 4 inches below the surface of the first good silage was 117° F. The silage improved with depth but there was considerable spoilage around the edge all the way down.

Silo No. 2 (acid-treated) was opened on November 10. The paper cap was completely disintegrated and there was much spoilage on top and for some distance in from the edge all the way down. The silage was dark colored, almost black in spots, and had a slightly disagreeable odor. The temperature 4 inches below the first good silage was 120° F. Little improvement was noted in this silage with depth.

### SPOILAGE

The amount of spoilage in each silo was so large that a calculation was made as to just what extent this occurred. The amount of green material put into each silo was known, as was the dry-matter content. The amount of each

silage fed was recorded, and several dry-matter determinations on the silage as fed afforded a means for determining the dry matter recovered. Table 1 illustrates the extent of loss that occurred. It must be remembered, however, that once the silos were opened no protection from the weather was afforded. Consequently, considerable spoilage may have taken place after feeding had begun.

TABLE 1.—Extent of Spoilage in Temporary Silos

	No. 1, untreated silage	No. 3, molasses- treated silage	No. 2, acid- treated silage
Total green weight put in, lb.	4,665	11,470	8,000
Dry matter, pct.	32.5	29.0	44.0
Total dry weight put in, lb.	1,516	3,326	3,520
Total green weight fed out, lb.	2,448	4,615	1,805
Dry matter, pct.	31.3	23.0	32.7
Total dry matter fed out, lb.	766	1,061	590
Loss in dry weight, lb.	750	2,265	2,930
Loss in dry weight, pct.	49.5	68.1	83.2

Silo No. 1 was opened finally on October 4, after having been found in excellent condition on August 13. Silo No. 3 was opened on October 16 and silo No. 2, on November 10. It would seem as though the degree of spoilage progressed with the length of time the silos remained unopened. It was noted, however, that the paper linings in silos No. 2 and No. 3 were in poorer condition than that of silo No. 1. This may have been as great a factor as time.

### CAROTENE PRESERVATION

The making of legume silage usually results in the preservation of the yellow pigment, carotene, which is required by cows and which is responsible for the yellow color in butterfat. To determine the effectiveness of carotene preservation in these temporary silos, samples of material as it went into the silo and of the silage as fed were analyzed for carotene.

On a dry-matter basis, all of these silages contained much more carotene than is usually found in alfalfa hay fed in Ohio. Hay containing 25 to 35 parts per million of carotene is good hay; most hay, however, contains less than 25 parts per million. The unusually high figure given for the carotene content of molasses silage cannot be explained, but it is in accordance with values obtained at this Station and elsewhere for some molasses- or acid-treated silage.

TABLE 2.—Carotene Preservation in Temporary Silos

	Air-dry matter	Acidity	Carotene
	<i>Pct.</i>	<i>pH</i>	<i>P. p. m.</i>
Untreated silo			
As put in	32.5	5.73	153.2
As taken out	31.3	6.13	86.0
Molasses silo			
As put in	29.0	5.61	144.3
As taken out	23.0	4.60	236.8
A. I. V. silo			
As put in	44.0	5.69	144.6
As taken out	32.7	4.10	71.2

## CAROTENE CONTENT OF BUTTERFAT

The feeding of carotene-rich roughage during the winter may be a means of preventing the marked loss of yellow color that occurs in milk and butterfat as the winter feeding season progresses. In keeping with routine procedure, the carotene content of butterfat produced by cows fed legume silage from the temporary silos was followed. Eight cows (four Holsteins and four Jerseys) that had been in pasture were divided into two groups of four cows each. One group was fed legume silage and alfalfa hay; the other was fed corn silage and alfalfa hay. Two other cows (one Jersey and one Holstein) that had been on corn silage and hay were started on legume silage and hay, and a similar group of two cows was continued on corn silage and hay. Only one cow in this last group yielded suitable data; the other was removed from the herd shortly after the experiment started. The silage and hay were fed according to live weight and varied from 10 to 14 pounds daily of hay and from 26 to 30 pounds daily of silage. Grain was fed according to production.

Samples of milk were obtained from each cow at the beginning of the experiment and during the last few days of each feeding period. These samples were separated, churned, and rendered into pure fat, on which the carotene determinations were made.

From Table 3 it will be seen that in general the fat of cows receiving legume silage and hay after having been on pasture lost carotene less rapidly than did that from cows fed corn silage and hay, and that the cows which had been on corn silage and hay previously increased the carotene content of their butterfat after being on the legume silage and hay. The high carotene value found for the molasses silage is reflected somewhat in the data, although all the periods were of too short duration to make the picture clear cut. The most that can be said is that the carotene content of the silage as determined chemically was reflected in the carotene content of the butterfat produced when the silages were fed.

TABLE 3.—Carotene Content of Butterfat Produced When  
Various Roughages were Fed  
(Expressed in parts per million)

Group	Cow No.	Begin- ning, Sept. 29- Oct. 2	End of un- treated silage feeding, Oct. 12-15	End of mo- lasses silage feeding, Nov. 1-4	End of acid silage feeding, Nov. 16-19
Hay silage and hay (following pasture)	H 410	8.0	7.0	4.7	3.6
	H 508	4.8	3.2	3.0	2.6
	J 477	11.3	11.7	10.3	6.6
	J 471	12.2	10.8	10.8	7.0
Average.....		9.1	8.2	7.2	5.0
Corn silage and hay (follow- ing pasture)	H 415	4.0	4.2	3.7	3.0
	H 463	5.1	3.7	3.2	2.3
	J 481	12.2	8.2	9.3	4.3
	J 499	12.2	10.5	5.3	3.6
Average.....		8.4	6.7	5.4	3.3
Hay silage and hay (follow- ing corn silage and hay)	H 486	1.5	1.3	2.3	2.2
	J 503	3.2	5.3	8.0	6.6
Average.....		2.4	3.3	5.7	4.4
Corn silage and hay (follow- ing corn silage and hay)	J 517	3.4	2.3	4.1	3.8

### PALATABILITY

Corn silage and either the untreated silage or the molasses silage were placed in adjoining sections of a long feed trough and made available to several dry cows. Without exception, each cow showed a decided preference for the corn silage. This is in keeping with previous experience at this Station and elsewhere.

### DISCUSSION

The construction of the temporary silos used in this work was found to be a very simple procedure. The most laborious job consisted of wiring the rings of fence together. Some difficulty was experienced in maintaining good joints where the sheets of paper overlapped, and with one silo the placement of the second ring of fence over the first was unsatisfactory and resulted in some tearing of the paper by the pickets as settling occurred. With more experience, however, it is felt that these difficulties could easily be eliminated.

The rather large amount of spoilage that occurred may have been due to several causes. Mechanical injury to the paper certainly was a contributing factor, as was high external temperature. Lack of protection from the weather after the silos were once opened afforded another source of spoilage. The fact that the untreated silage was in perfect condition when first inspected (3 weeks after ensiling) and showed considerable edge spoilage 7 weeks later is indicative of the harmful effect of prolonged exposure to external conditions naturally conducive to spoilage.

Loosening of the silage from the paper may have caused the edge spoilage. The small diameter of these temporary silos may have been favorable to this, although where similar edge spoilage has been noted in permanent silos it has been attributed to improper tramping or leaky staves and doors.

Silos of this type may not be suited for ensiling an early season crop for use the following winter because of excessive loss through spoilage. A short rather than a long period of storage would seem more desirable. In a permanent silo the length of period makes little difference. Because it is necessary to feed the silage down rapidly to keep ahead of spoilage, such silos would better serve to feed a large herd for a short time than a smaller herd for an extended period.

In the case of the acid-treated silage it is not so difficult to explain the greater amount of spoilage. Before the filling of this silo had even been completed, acid spray had caused the outside of the paper to crack and fray in many places. As the silage was fed out of this silo it was noted that the paper lining was very badly damaged. To attempt to ensile a legume by the acid-treatment method in temporary silos of this type would, in our opinion, be inviting spoilage.

Except for the acid-treated material, the actual quality of the silage suitable for feeding was not much different from that of similar silages put up in larger, permanent silos.

### SUMMARY

Untreated, molasses-treated, and acid-treated alfalfa (second-cutting) were ensiled in small temporary silos of the snow-fence type. After 10 to 15 weeks the silos were opened, and the silage was examined and fed.

Considerable edge spoilage and some top spoilage were found in the untreated and molasses-treated silos. Much top and edge spoilage was found in the acid-treated silo.

Carotene content and feeding quality of the unspoiled silage were not much different from those of similar silages made in permanent silos.

### SUGGESTIONS AND PRECAUTIONS

The limited data obtained in this trial indicate that legumes probably can be ensiled in temporary silos for short periods with about as much certainty as in permanent silos.

To reduce the proportion of edge spoilage, the silo should be not less than 12 feet in diameter.

The green material should be well tramped around the edge.

Some type of protective covering should be provided after the silo is opened, and feeding should be rapid.

Because of damage to the paper lining, the acid treatment should not be used.

Legume silage should not be kept in temporary silos too long during hot weather.

Temporary silos are best adapted to storing a late crop for feeding in the fall or early winter to supplement and extend the use of a permanent silo.

# FATTENING STEER CALVES

## Quantity of Supplement, III

PAUL GERLAUGH

This test is the third of a series. The results of the first test were reported in Bimonthly Bulletin 179; those of the second, in Bimonthly Bulletin 186.

The results of the first 2 years indicated that 0.8 pound of supplement daily per calf throughout the feeding period was not sufficient for most satisfactory gains or finish. This ration was not included in the third year's test.

During each of the first two tests, a lot was included which was fed 2.4 pounds of supplement daily per calf during the first 12 weeks, then dropped to 1.6 pounds during the second 12-week period, then to 0.8 pound during the third period of 12 weeks, and was fed no supplement during the fourth period, which was 8 weeks in the first test and 12 weeks in the second. The two tests each showed that the removal of all the supplement gave poor performance and that lowering the supplement to the 0.8-pound a day level was not good procedure. This ration was dropped from the third test, though a ration was included which fed less supplement as the feeding period advanced, but not to as low levels.

The calves used in this test were Herefords from southwestern Texas. They arrived in Wooster November 17, 1936, and cost \$8.50 per hundredweight, delivered. They were started on test December 8, weighing slightly under 350 pounds.

The same supplement was used in this test as was used in the two preceding tests. It was a mixture of 30 parts dry-rendered tankage, 30 parts soybean oil meal, 20 parts cottonseed meal, 15 parts linseed meal, 2 parts finely ground limestone, 2 parts special steamed bone meal, and 1 part salt.

The same amount of silage and mixed clover and timothy hay was fed to all lots and corn was full-fed to all lots.

Lot 1 was fed 1.6 pounds of supplement daily per steer throughout the test. Lot 3 was fed 2.4 pounds daily per steer throughout the test. Lot 4 was fed 2.4 pounds per steer during the first two periods of 12 weeks each and 1.6 pounds during the third period of 12 weeks and the fourth period of 8 weeks. Lot 5 was fed 1.6 pounds per steer during the first two periods and raised to 2.4 pounds during the last two periods. Lot 2 was fed 0.8 pound during the first period, 1.6 pounds during the second period, 2.4 pounds during the third period, and 3.2 pounds during the fourth period.

In Table 1, showing gains by periods and the amounts of supplement fed, it is readily seen that the gains in each of the periods are largest in the lots fed the most supplement. The performance of Lot 3 during the fourth period is the exception to this statement. Lot 2 was considered the ripest lot of cattle, also the most attractive, if one were looking for a compactly made animal. This lot had gained noticeably less during the first and second periods, but, as the amount of supplement fed them was increased, their gains increased in relation to those of the other lots. This lot of cattle looked as if they were demonstrating a very desirable feeding procedure, if one were primarily interested in the production of show cattle. Similarly fed lots during the 2 preceding years showed the same performance.

Lot 4 steers slowed up materially when their supplement was reduced from 2.4 pounds to 1.6 pounds at the start of the third period, in comparison with the performance of Lot 5, whose supplement was increased from 1.6 to 2.4 pounds at the same time. Lot 2 responded in relation to the other lots each period as their supplement was increased.

TABLE 1.—Quantity of Supplement, III

Dec. 8, 1936, to Oct. 12, 1937 (308 days)	Lot 1	Lot 2	Lot 3	Lot 4	Lot 5
Number of steers per lot.....	20	20	20	20*	20†
Cost per cwt. at start, dol.....	8.50	8.50	8.50	8.50	8.50
Average weight, start of test, lb.....	345	344	349	348	345
Average weight, close of test, lb.....	982	1002	1020	1008	1025
Average daily gain, first period, lb.....	2.06	1.87	2.16	2.11	2.05
Average daily gain, second period, lb....	2.54	2.47	2.64	2.52	2.51
Average daily gain, third period, lb.....	1.87	2.16	2.05	1.98	2.24
Average daily gain, fourth period, lb.....	1.67	1.99	1.71	1.74	1.86
Average daily gain, 308 days, lb.....	2.07	2.13	2.18	2.12	2.19
Average daily ration, 308 days, lb.:					
Shelled corn.....	10.44	10.35	10.32	10.34	10.38
Supplement.....	1.6	1.89	2.4	2.04	1.96
Silage.....	7.0	7.0	7.0	7.0	7.0
Hay.....	1.54	1.54	1.54	1.54	1.54
Feed per cwt. of gain, lb.:					
Shelled corn.....	505.0	485.2	473.8	487.3	474.2
Supplement.....	77.4	88.6	110.1	96.3	89.5
Silage.....	338.5	328.0	321.3	329.9	319.7
Hay.....	74.7	72.4	70.9	72.9	70.7
Cost per cwt. of gain, dol.....	14.42	14.17	14.35	14.38	13.89
Selling price in lot, dol. (3 per cent shrink)	19.00	19.00	19.00	19.00	19.00
Dressing percentage.....	62.66	62.51	61.64	63.47	62.56
Carcass grade:					
Prime.....	20	20	18	18	16
Choice.....	0	0	2	0	3
Bushels of corn fed per steer.....	57.4	56.9	56.7	56.8	57.0
Pounds of supplement fed per steer.....	493	582	741	629	603
Gain on hogs per lot, lb.....	1187	1255	1315	1177	1250
Gain on hogs per bushel of corn fed to steers, lb.....	1.03	1.10	1.16	1.08	1.14

\*Steer removed March 21, and one on September 7.

†Steer removed April 27.

FEED PRICES: Corn, first period, 98 cents per bushel; second period, \$1.26; third period, \$1.30; fourth period, \$1.26. Supplement, \$42.50 per ton; silage, \$6.50 per ton; hay, \$15.00 per ton.

The killing report on all lots was very satisfactory. The cattle were held in New York from Monday to Friday before being killed. This may have had some influence upon the dressing percentages.

During the period of this test corn prices were abnormally high; whereas prices of supplement were only slightly increased. This price situation made the feeding of the larger amounts of supplement more profitable than would usually be the case.

# FATTENING STEER CALVES—QUANTITY OF SUPPLEMENT TEST

## Summary of Three Years

PAUL GERLAUGH

Calves in the feed lot present problems that are noticeably different from those in the feeding of older cattle.

A larger portion of the gain of calves consists of growth than is the case with older cattle. Tissues of growth are higher in proteins than is fatty tissue. To both grow and fatten require a longer feeding period for calves than is necessary for older cattle.

Hays, particularly the legumes, contain much more protein than does corn, and the proteins of hays are known as good proteins. Hays are bulky and calves cannot eat enough hay to meet protein requirements and enough corn to get fat. For calf fattening rations, it is best to rely upon obtaining most of the additional protein from concentrates rather than from hays, under anything like normal price relationships of corn, protein concentrates or supplement, and hay.

This test was planned to obtain further information on the preferable quantity of supplement to use in the ration for fattening calves and to learn the advantages or handicaps of increasing or decreasing the amount of supplement as the feeding period advances.

A definite amount of supplement was fed per calf daily rather than a ratio of supplement to corn, because of the rapidly increasing amount of concentrates, corn and supplement, which calves consume during their first several months' stay in the feed lot.

The supplement used throughout the three tests was the same. It was a mixture of tankage, 30 parts; soybean oil meal, 30 parts; cottonseed meal, 20 parts; linseed meal, 15 parts; finely ground limestone, 2 parts; special steamed bone meal, 2 parts; and salt, 1 part. It analyzed 45 to 46.5 per cent protein. As much protein is contained in 0.8 pound of this mixture as is contained in 1 pound of a mixture of equal parts of linseed meal and cottonseed meal.

For several years before this test, this Station had tested the value of the two mixtures and had found that the supplement containing the tankage was preferable to the supplement of vegetable proteins, when measured by rapidity of gains, finish, and economy.

Mixed clover and timothy hay was used throughout. It is realized that a straight legume hay would doubtless be preferable, but many farmers have mixed hay. It is probably safe to say that the man who has legume hay would doubtless get somewhat faster performance than the man who uses mixed hay, although with the small amount of hay fed, the difference would not be as great as might be hoped for.

The feeding of calves does not permit the feeding of large enough quantities of hay to capitalize upon the advantages of legume hay. Especially is this true if silage is used as a part of the ration. Calves need be limited in grain consumption if large quantities of hay are to be consumed. If the grain consumption is limited, the calves will not fatten rapidly enough to sell to good advantage.

Silage was also fed in seemingly small quantities in these tests for the same reasons as mentioned for hay. It is doubtful if ever the calves wanted more silage or hay than they were fed during the tests. Shelled corn was used. Work done by this Station has shown corn-and-cob meal to be preferable to shelled corn for fattening cattle, but the location of the Station with respect to the corn belt territory makes the using of shelled corn more desirable. Flake salt was available at all times.

Hereford calves were used in all the tests. In all cases they were of choice quality. The Eastern Order Buying Company purchased all the calves and much credit is due them for the quality selected for use. Nineteen or twenty head of calves were started in each of the lots. The tests were started during late November and December in keeping with prevalent farm practice.

A relatively long feeding period was followed in each of the tests. In fact the cattle were "finished" in each of the tests. It is doubtful whether markets have the ability to absorb a large increase in the number of cattle of this degree of fatness. For those who are interested in a shorter feeding period, the performance of each test is shown in three periods of 12 weeks each for all lots; a fourth period of 12 weeks is shown the second year; and a fourth period of 8 weeks is shown the first and third years.

**TABLE 1.—Quantity of Supplement Test**  
Corn and supplement consumption and gains by periods  
December 11, 1934, to October 15, 1935—308 days

	Lot 1	Lot 2	Lot 3	Lot 4	Lot 5
Weight of calves, start of test, lb.....	404	402	403	407	404
First period, 12 weeks:					
Daily corn consumption, lb.....	8.48	8.51	7.94	7.94	8.04
Daily supplement consumption, lb.....	0.8	0.8	2.4	2.4	1.6
Total corn and supplement, lb.....	9.28	9.31	10.34	10.34	9.64
Average daily gain, lb.....	2.41	2.45	2.57	2.58	2.48
Second period, 12 weeks:					
Weight of calves, start of period, lb.....	607	608	620	624	613
Daily corn consumption, lb.....	12.34	12.34	11.33	12.25	12.25
Daily supplement consumption, lb.....	0.8	1.6	2.4	1.6	1.6
Total corn and supplement, lb.....	13.14	13.94	13.73	13.85	13.85
Average daily gain, lb.....	2.46	2.66	2.61	2.74	2.81
Third period, 12 weeks:					
Weight of calves, start of period, lb.....	813	831	839	850	849
Daily corn consumption, lb.....	13.75	13.80	13.46	14.63	15.05
Daily supplement consumption, lb.....	0.8	2.4	2.4	0.8	1.6
Total corn and supplement, lb.....	14.55	16.20	15.86	15.43	16.65
Average daily gain, lb.....	1.81	2.06	2.13	2.02	2.20
Fourth period, 8 weeks:					
Weight of calves, start of period, lb.....	965	1014*	1018	1025	1029*
Daily corn consumption, lb.....	13.60	13.39	13.08	15.08	14.84
Daily supplement consumption, lb.....	0.8	3.2	2.4	0	1.6
Total corn and supplement, lb.....	14.40	16.59	15.48	15.08	16.44
Average daily gain, lb.....	1.68	2.16	1.84	1.77	1.89
Weight of calves, close of test, lb.....	1059	1134	1121	1124	1135

\*Steer removed previous period.

The silage and hay consumption was the same for all lots each period.

Tables 1, 2, and 3 show the corn and supplement consumption and the gains of the various lots by periods for each year. There are few exceptions in the tables to the statement that total concentrate, corn and supplement, consump-

tion is influenced by the amount of supplement fed. The larger amounts of supplement fed have invariably been associated with larger concentrate consumption. This situation is probably due, in part, to the palatability of the supplement as compared with corn, and in part to the increased growth in the lots receiving the larger amounts of supplement in the first period, giving these calves more capacity. Also, increased amounts of supplement may stimulate the appetites of the cattle to some extent. Regardless of the reason, increased amounts of supplement fed resulted in the steers' eating more feed and invariably making more gain.

TABLE 2.—Quantity of Supplement Test

Corn and supplement consumption and gains by periods  
November 19, 1935, to October 20, 1936—336 days

	Lot 1	Lot 2	Lot 3	Lot 4	Lot 5
Weight of calves, start of test, lb. ....	341	343	346	345	346
First period, 12 weeks:					
Daily corn consumption, lb. ....	5.31	5.28	5.03	5.03	5.03
Daily supplement consumption, lb. ....	0.8	0.8	2.4	2.4	1.6
Total corn and supplement, lb. ....	6.11	6.08	7.43	7.43	6.63
Average daily gain, lb. ....	1.77	1.70	2.16	2.07	1.97
Second period, 12 weeks:					
Weight of calves, start of period, lb. ....	490	486*	503	519	511
Daily corn consumption, lb. ....	10.19	10.10	9.65	9.69	9.69
Daily supplement consumption, lb. ....	0.8	1.6	2.4	1.6	1.6
Total corn and supplement, lb. ....	10.99	11.70	12.05	11.29	11.29
Average daily gain, lb. ....	2.17	2.30	2.28	2.24	2.20
Third period, 12 weeks:					
Weight of calves, start of period, lb. ....	676*	680	719	708	696
Daily corn consumption, lb. ....	13.31	13.09	12.80	13.31	13.23
Daily supplement consumption, lb. ....	0.8	2.4	2.4	0.8	1.6
Total corn and supplement, lb. ....	14.11	15.49	15.20	14.11	14.83
Average daily gain, lb. ....	1.87	2.34	2.20	1.90	2.15
Fourth period, 12 weeks:					
Weight of calves, start of period, lb. ....	833	876	904	868	877
Daily corn consumption, lb. ....	14.30	13.30	13.73	14.94	14.38
Daily supplement consumption, lb. ....	0.8	3.2	2.4	0	1.6
Total corn and supplement, lb. ....	15.10	16.50	16.13	14.94	15.98
Average daily gain, lb. ....	1.60	1.62	1.69	1.31	1.71
Weight of calves, close of test, lb. ....	968	1013	1046	977	1020

\*Steer removed previous period.

The same amount of silage and hay was fed to all lots each period.

Weekly weights were taken. In each case when a lot of calves was shifted to a higher level of supplement, an immediate response in the daily gains of the calves was noted. When the supplement was dropped from 2.4 pounds daily to 1.6 pounds daily, the slowing up was not so abrupt. However, when the supplement was dropped from 1.6 pounds to 0.8 pound, or from 0.8 pound to no supplement, the slowing up of the gains of the calves was promptly noticed, and the gains remained on a much reduced level.

Our observations lead us to feel that the amount of supplement fed has considerable influence upon the attractiveness of hair coats. At levels of less than 1.6 pounds of supplement, the hair coats did not have the gloss that one likes to see. When 1.6 pounds of supplement were fed, the hair coats would be called satisfactory, though not as attractive as when the larger quantities were fed. The larger quantities of supplement fed are associated with more "bloom" in the appearance of the animals.

At none of the levels at which supplement was fed did the steers show an objectionable looseness of the bowels. The steers were looser when fed the larger quantities of supplement as compared with the lower levels.

There is considerable difference in the average daily gains from year to year. The steers used in the 1934-1935 tests made unusually good gains throughout the test. These cattle were about 60 pounds heavier at the start of the test, though this is only partly responsible for the increased gains. We do not know the full explanation.

**TABLE 3.—Quantity of Supplement Test**  
Corn and supplement consumption and gains by periods  
December 8, 1936, to October 12, 1937—308 days

	Lot 1	Lot 2	Lot 3	Lot 4	Lot 5
Weight of calves, start of test, lb. ....	345	344	348	348	345
First period, 12 weeks:					
Daily corn consumption, lb. ....	5.65	5.77	5.65	5.65	5.65
Daily supplement consumption, lb. ....	1.6	0.8	2.4	2.4	1.6
Total corn and supplement, lb. ....	7.25	6.57	8.05	8.05	7.25
Average daily gain, lb. ....	2.06	1.87	2.16	2.11	2.05
Second period, 12 weeks:					
Weight of calves, start of period, lb. ....	518	500	530	527*	522*
Daily corn consumption, lb. ....	11.01	11.04	10.78	10.78	10.97
Daily supplement consumption, lb. ....	1.6	1.6	2.4	2.4	1.6
Total corn and supplement, lb. ....	12.61	12.64	13.18	13.18	12.57
Average daily gain, lb. ....	2.54	2.47	2.64	2.52	2.51
Third period, 12 weeks:					
Weight of calves, start of period, lb. ....	732	709	752	739	732
Daily corn consumption, lb. ....	13.15	13.03	12.95	13.17	13.13
Daily supplement consumption, lb. ....	1.6	2.4	2.4	1.6	2.4
Total corn and supplement, lb. ....	14.75	15.43	15.35	14.77	15.53
Average daily gain, lb. ....	1.87	2.16	2.05	1.98	2.24
Fourth period, 8 weeks:					
Weight of calves, start of period, lb. ....	888	890	924	905*	920
Daily corn consumption, lb. ....	12.70	12.19	12.70	12.92	12.84
Daily supplement consumption, lb. ....	1.6	3.2	2.4	1.6	2.4
Total corn and supplement, lb. ....	14.30	15.39	15.10	14.52	15.24
Average daily gain, lb. ....	1.67	1.99	1.71	1.74	1.86
Weight of calves, close of test, lb. ....	982	1002	1020	1008	1025

\*Steer removed previous period.

Same amount of silage and hay fed to all lots each period.

The cattle of the 1935-1936 test were in the feed lot during the coldest winter and the hottest summer that have occurred in this territory for a long time. They were on test 4 weeks longer than either of the other groups and were considered the fattest of three groups of cattle at the close of the test.

There is little difference in the feed requirements per hundred pounds of gain in the three groups of cattle when the difference in length of feeding period is considered.

There is little doubt in the minds of those who saw the cattle as the tests progressed that the lots receiving the larger amounts of supplement in the early part of the test made more growth but showed no more thickness of flesh until on test approximately 6 months. Certainly, the cattle that received 2.4 pounds of supplement throughout the test had a very different appearance at the close of the test from that of the steers that were fed 0.8 pound of supplement during the first period and increased on up to 3.2 pounds during the last period. Cattle

that start on the lower levels do not show the size at the close of the test. Increasing the supplement as the feeding period advances will hasten the fattening on these smaller bodies. Each year the Lot 3 cattle were noticeably larger than the Lot 2 cattle. The Lot 2 cattle were not so well finished as the Lot 3 cattle until they got into their fourth period and were fed 3.2 pounds of supplement. On this latter level they finished rapidly and always closed the test with the appearance of being as well finished as any group. Low supplement levels require longer feeding periods to obtain desirable finish.

TABLE 4.—Quantity of Supplement Test

Summary, 1934-1935

December 11, 1934, to October 15, 1935—308 days

	Lot 1	Lot 2	Lot 3	Lot 4	Lot 5
Number of calves.....	19	20*	20	20	20†
Cost per cwt., dol.....	6.25	6.25	6.25	6.25	6.25
Average weight, start of test, lb.....	404	402	403	407	404
Average weight, close of test, lb.....	1059	1134	1121	1123	1135
Average daily gain, lb.....	2.13	2.35	2.33	2.33	2.39
Average daily ration, lb.:					
Shelled corn.....	11.9	11.8	11.3	12.24	12.27
Supplement.....	0.8	1.88	2.4	1.3	1.6
Silage.....	6.91	6.91	6.91	6.91	6.91
Hay.....	1.86	1.86	1.86	1.86	1.87
Feed per cwt. of gain, lb.:					
Corn.....	559.1	503.2	484.8	525.9	512.5
Supplement.....	37.6	79.8	102.9	56.2	66.8
Silage.....	324.6	293.9	296.3	296.9	288.5
Hay.....	87.5	79.5	79.9	80.1	77.9
Cost per cwt. of gain (1), dol.....	10.53	10.52	10.79	10.33	10.33
Gain on hogs per bu. of corn fed to steers, lb.....	1.17	1.33	1.23	1.16	1.27
Selling price, feed lot weight, less 3 per cent, dol.....	11.75	12.75	12.75	12.75	12.75
Cost per cwt. of gain (2), dol.....	6.72	6.97	7.26	6.70	6.77
Cost per cwt. of gain (3), dol.....	12.68	12.57	12.83	12.40	12.38

Feed prices:	Corn per bu.	Supplement per ton	Silage per ton	Hay per ton
(1).....	\$0.80	\$45.00	\$5.50	\$18.00
(2).....	0.50	40.00	3.50	9.00
(3).....	1.00	50.00	6.50	16.00

\*Steer removed July 23.

†Steer removed May 22.

The economy of feeding different quantities of supplement is, to some extent, dependent upon relative prices of corn and supplement. It is doubtful if prices would often be such as to justify limiting the supplement for calves to 0.8 pound per day. The use of older cattle in the feed lot would doubtless be preferable.

Each year's summary shows costs of gains at prices prevailing that year in this territory. Each summary also shows a cost of gain on comparatively high-priced corn and another level showing comparatively low-priced corn. Obviously, there are many price combinations not shown in these tables.

In addition to the cost of a hundredweight of gain, one must remember that the selling value of the cattle is to be considered. There is a price handicap to certain lots of cattle when all lots are sold at the same time. We have always

had the lots which received no supplement during the last period or the lots receiving 0.8 pound of supplement throughout the test pointed out as being less desirable than the other lots at selling time.

TABLE 5.—Quantity of Supplement Test

Summary, 1935-1936

November 19, 1935, to October 20, 1936—336 days

	Lot 1	Lot 2	Lot 3	Lot 4	Lot 5
Number of steers .....	19*	19†	20	20	20
Cost per cwt., dol. ....	9.75	9.75	9.75	9.75	9.75
Average weight, start of test, lb. ....	341	342	346	345	346
Average weight, close of test, lb. ....	968	1013	1046	978	1020
Average daily gain, lb. ....	1.85	1.99	2.08	1.88	2.01
Average daily ration, lb.:					
Shelled corn .....	10.70	10.42	10.30	10.74	10.58
Supplement .....	0.8	2.0	2.4	1.2	1.6
Silage .....	7.00	7.00	7.00	7.00	7.00
Hay .....	1.54	1.54	1.54	1.54	1.54
Feed per cwt. of gain, lb.:					
Corn .....	577.5	523.8	494.6	570.7	527.5
Supplement .....	43.5	100.3	115.2	63.7	79.8
Silage .....	377.6	352.0	336.7	371.8	349.0
Hay .....	83.3	77.6	74.0	81.9	76.8
Cost per cwt. of gain (1), dol. ....	10.30	10.51	10.41	10.70	10.27
Gain on hogs per bu. of corn fed to steers, lb. ....	0.73	0.82	0.91	0.75	0.95
Selling price, feed lot weight, less 3 per cent, dol. ....	11.00	11.50	11.50	11.10	11.15
Cost per cwt. of gain (2), dol. ....	7.05	7.64	7.64	7.39	7.26
Cost per cwt. of gain (3), dol. ....	13.29	13.62	13.40	13.64	13.16

Feed prices:	Corn per bu.	Supplement per ton	Silage per ton	Hay per ton
(1)..... }	\$0.50 to July 1	{ \$39.50	\$4.00	\$10.00
(2)..... }	1.00 July 1 to close			
(3)..... }	0.50	40.00	3.50	9.00
(3)..... }	1.00	50.00	6.50	16.00

\*Steer removed March 5.

†Steer removed January 7.

Sometimes this difference in appearance resulted in price variations between the lots and sometimes all lots sold as a unit even though a difference was apparent. The killing sheets showed less difference between the lots than the on-foot appearances.

The economy of the different quantities of supplement is dependent upon the relative prices of supplement and corn. Following the 1936 drouth, corn prices practically doubled in value; whereas the price of supplement advanced 20 to 25 per cent. This price situation would favor the more liberal use of supplement.

The work at this Station indicates:

1. Eight-tenths pound of a 45 per cent supplement is not an adequate amount of supplement to use throughout a fattening period for steer calves.
2. One and six-tenths pounds of supplement is a very safe amount to use throughout a fattening period. This amount will never be far wrong.
3. Two and four-tenths pounds of supplement can be counted on to produce fatter calves in a feeding period of 6 months or longer than a smaller amount. The faster gains will probably cost a little more.

4. Reducing the supplement as the feeding period advances is a doubtful procedure.

5. Increasing the supplement as the feeding period advances is good procedure from some angles. Lot 2 ration always made steers look better adapted for a show ring than that of any of the other lots. For commercial feeding, starting at a higher level is recommended

TABLE 6.—Quantity of Supplement Test

Summary, 1936-1937

December 8, 1936, to October 12, 1937—308 days

	Lot 1	Lot 2	Lot 3	Lot 4	Lot 5
Number of steers per lot .....	20	20	20	20*	20†
Cost per cwt., dol. ....	8.50	8.50	8.50	8.50	8.50
Average weight, start of test, lb. ....	345	344	349	348	345
Average weight, close of test, lb. ....	982	1002	1020	1008	1025
Average daily gain, lb. ....	2.07	2.13	2.18	2.12	2.19
Average daily ration, lb.:					
Shelled corn .....	10.44	10.35	10.32	10.34	10.38
Supplement .....	1.6	1.89	2.4	2.04	1.96
Silage .....	7.0	7.0	7.0	7.0	7.0
Hay .....	1.54	1.54	1.54	1.54	1.54
Feed per cwt. of gain, lb.:					
Corn .....	505.0	485.2	473.8	487.3	474.2
Supplement .....	77.4	88.6	110.1	96.3	89.5
Silage .....	338.5	328.0	321.3	329.9	319.7
Hay .....	74.7	72.4	70.9	72.9	70.7
Cost per cwt. of gain (1), dol. ....	14.42	14.17	14.35	14.38	13.89
Gain on hogs per bushel of corn fed to steers, lb. ....	1.03	1.10	1.16	1.08	1.14
Selling price, feed lot weight, less 3 per cent, dol. ....	19.00	19.00	19.00	19.00	19.00
Cost per cwt. of gain (2), dol. ....	6.98	7.00	7.31	7.18	6.90
Cost per cwt. of gain (3), dol. ....	12.65	12.52	12.82	12.76	12.31

## FEED PRICES:

(1) Corn 98 cents per bushel first period; \$1.26 per bushel second period; \$1.30 per bushel third period; \$1.26 per bushel fourth period

Supplement, \$42.50; silage, \$6.50; hay, \$15.00 per ton.

(2) Corn, 50 cents per bushel; supplement, \$40.00 per ton; silage, \$3.50 per ton; hay, \$9.00 per ton

(3) Corn, \$1.00 per bushel; supplement, \$50.00 per ton; silage, \$6.50 per ton; hay, \$16.00 per ton.

\*Steer removed March 21 and one September 7.

†Steer removed April 27.

# REDUCING THE AMOUNT OF CORN AND INCREASING THE AMOUNT OF LEGUME HAY IN RATIONS FOR FATTENING YEARLING STEERS, II

PAUL GERLAUGH AND C. W. GAY

This test was conducted in the feed lots of the Ohio State University and was under the supervision of C. W. Gay. The test was a repetition of the test conducted during 1935-1936, the results of which were reported in Bimonthly Bulletin 186 of the Ohio Agricultural Experiment Station.

Choice quality Hereford steers, weighing about 720 pounds, were used in the 252-day test, which started December 10, 1936. The same amount of silage and supplement was fed to all lots throughout the test. During the hot weather the Lot 1 cattle did not clean up their silage as well as did Lots 2 and 3. This accounts for their smaller silage consumption as shown in Table 1.

TABLE 1.—Reducing the Corn and Increasing the Hay for  
Yearling Steers, 1936-1937

Dec. 10, 1936, to Aug. 19, 1937 (252 days)	Lot 1 Full feed of corn	Lot 2 Three-fourths full feed of corn	Lot 3 One-half full feed of corn
Number of steers per lot .....	12	12†	12
Cost per cwt. in feed lot, dol. ....	8.75	8.75	8.75
Average weight, Dec. 10, lb. ....	722	724	716
Average weight, Aug. 19, lb. ....	1187	1196	1159
Average daily gain, lb. ....	1.85	1.76	1.75
Average ration, lb.:			
Corn-and-cob meal .....	13.20	10.05	6.70
Supplement .....	1.44	1.44	1.44
Silage .....	14.6	15.0	15.0
Hay .....	3.84	7.38	9.92
Feed per cwt. of gain, lb.:			
Corn-and-cob meal .....	714.7	571.0	381.6
Supplement .....	78.0	81.9	82.1
Silage .....	793.4	852.2	854.2
Hay .....	208.1	419.5	565.0
Cost per cwt. of gain, dol. ....	18.26	18.38	16.82
Pounds of gain on hogs per lot .....	547	415	278
Acres of feed per lot:*			
Corn .....	11.40	8.64	5.79
Silage .....	2.23	2.26	2.27
Hay .....	2.91	5.56	7.50
Total acres per lot .....	16.54	16.46	15.56
Total gain per lot, lb. ....	5584	5296	5310
Gain on cattle per acre, lb. ....	337.6	321.7	341.2
Gain on cattle and hogs per acre, lb. ....	370.6	346.9	359.1
Market appraisal of cattle, dol. ....	18.50	18.50	17.75

\*Corn, 50 bushels per acre; silage, 10 tons per acre; hay, 2 tons per acre.

†Steer died August 6, gains prorated.

FEED PRICES: Corn, \$1.12 per bushel; supplement, \$45.00 per ton; hay, \$20.00 per ton; silage, \$7.50 per ton.

Lot 1 was full-fed corn-and-cob meal; Lot 2 was fed three-fourths as much corn-and-cob meal as was fed to Lot 1; and Lot 3 was fed one-half as much corn-and-cob meal as was fed to Lot 1. Legume hay, alfalfa or clover, was fed

to each lot in amounts that the cattle would clean up. The same pigs followed all three lots of cattle. The gains on the pigs are prorated to the various lots of cattle in proportion to the amount of corn consumed by the cattle.

At the close of the test the cattle were sold by lots through the State Fair auction. Lots 1 and 2 were prime lots of cattle. Lot 3 was not so well finished. Several packer buyers expressed the opinion that Lot 3 was worth a dollar per hundredweight less than Lots 1 and 2. It sold for 75 cents per hundredweight less.

There was considerable saving in the cost of a hundredweight of gain in the lot fed half a full feed of corn. However, the lower selling price more than overcame the savings in feed costs. Seventy-five cents per hundred on the 1159-pound steers equals \$8.69 less per steer; \$8.69 divided by 443 pounds, the feed lot gain per steer in Lot 3, gives \$1.96 per hundredweight as representing the handicap of the gains on the Lot 3 steers as compared with Lots 1 and 2. The gains in Lot 3 cost just \$1.50 per hundred less than the average of Lots 1 and 2. The saving in cost of gains was not sufficient to overcome the handicap in selling price. There was also less gain on the hogs following the Lot 3 cattle.

## QUANTITY OF PROTEIN FOR YEARLING STEERS ON A HEAVY SILAGE RATION

Madison County, 1936-1937

PAUL GERLAUGH AND H. W. ROGERS

This test was conducted at the Madison County Experiment Farm, of which H. W. Rogers is superintendent.

The corn crop of 1936 at this farm was very severely handicapped by the drouth. Because of the light corn crop, it was decided to put as much of the corn crop into the silo as possible, in order to have sufficient feed for two lots of steers. Fifty-three acres of corn, yielding 198 tons of silage, were put into the two silos. Husking records show a yield of 15.5 bushels of corn per acre.

Yearling Shorthorn steers were used in the test. Each lot of steers was full-fed silage and given all the legume hay they wanted in addition.

One lot was fed 2 pounds daily per steer of a supplement containing soybean oil meal, 2 parts; tankage, 1 part; and cottonseed meal, 1 part. This supplement averaged 46 per cent protein.

The other lot was fed 2 pounds daily per steer of a supplement containing finely ground shelled corn, 4 parts; soybean oil meal, 2 parts; tankage, 1 part; and cottonseed meal, 1 part. This supplement averaged 29 per cent of protein. The corn meal was added to the supplement fed to the one lot of cattle to balance approximately the carbohydrate and fat content of the second pound of protein concentrates fed to Lot 2. The addition of the corn meal added some protein, so that it is not correct to assume that Lot 2 steers received twice as much protein in their supplement as was fed to Lot 1 steers in their supplement.

There was no apparent difference in the performance of the two lots of cattle at any time. There was no agreement among the people who saw the cattle after they had been on test at least 5 months as to the preferable lot in finish.

**TABLE 1.—Quantity of Protein for Yearling Steers on a Heavy Silage Ration**

Oct. 20, 1936, to April 20, 1937 (182 days)	Lot 1	Lot 2
Number of steers per lot .....	16	16
Cost per cwt. in lots, dol. ....	6.80	6.80
Average weight, start of test, lb. ....	730	730
Average weight, close of test, lb. ....	1120	1119
Average daily gain, lb. ....	2.14	2.14
Ration, lb.: .....		
Corn silage .....	48.07	48.25
Supplement* .....	1.96	1.96
Hay .....	2.84	2.84
Feed per cwt. of gain, lb.: .....		
Corn silage .....	2245	2259
Supplement .....	91.6	91.8
Hay .....	132.7	133.2
Cost per cwt. of gain, dol. ....	10.90	11.34
Market appraisal, feed lot weight, dol. ....	12.00	12.00

\*Supplement to Lot 1: ground shelled corn, 4 parts; soybean oil meal, 2 parts; cottonseed meal, 1 part; tankage, 1 part.

Supplement to Lot 2: soybean oil meal, 2 parts; cottonseed meal, 1 part; tankage, 1 part.

FEED PRICES: Ground shelled corn, \$1.00 per bushel; tankage, soybean oil meal, cottonseed mixture, \$45.00 per ton; silage, \$7.50 per ton; hay, \$12.00 per ton.

The results of the test indicate that with yearling steers fed a heavy silage ration and what legume hay they want, 1 pound of corn meal is as good an addition to 1 pound of 46 per cent protein concentrate as is a second pound of the protein concentrate.

During the 1930-1931 feeding period at this farm, two lots of 783-pound steers were fed a heavy silage ration with legume hay available in such quantities as the steers wanted. Two pounds of cottonseed meal were fed to one lot; 2 pounds of shelled corn were fed to the other lot. In this test the lot getting the 2 pounds of cottonseed meal gained 2.47 pounds daily per steer over a feeding period of 165 days; whereas the lot getting the 2 pounds of shelled corn gained 2.06 pounds daily per steer. These results are reported in Bimonthly Bulletin 151.

In the work with yearling steers on a heavy silage ration with excellent legume hay fed in such amounts as the steers wanted, 1 pound of ground shelled corn has satisfactorily replaced 1 pound, or one-half, of the protein concentrate. Trying to replace 2 pounds of protein concentrate with 2 pounds of shelled corn did not prove satisfactory.

After the test was closed on April 20, corn-and-cob meal was added in similar amounts to the ration of both lots and the test was continued for 58 days. At the end of this time, the Lot 1 steers showed an average daily gain of 2.02 pounds; whereas Lot 2 showed a gain of 2.00 pounds daily. There was no apparent difference in the appearance of the two lots of cattle at the end of the 240 days. They were sold at \$13.50 for 26 head and \$12.50 for 6 head.

# SKIMMED MILK AND DRIED SKIMMED MILK FOR PIGS

W. L. ROBISON

## IRON AND VITAMINS A AND D DEFICIENT IN SKIMMED MILK

Skimmed milk is an effective protein supplement to corn or other grain for pigs. Buttermilk is similar to skimmed milk in composition and feeding value. Both are deficient in vitamins A and D and in iron. Since the ultraviolet rays of the sun, like vitamin D, aid in the assimilation of minerals, supplying vitamin D is of less importance when the pigs are exposed to the sun than when they are not. Vitamin A, other vitamins, proteins, and minerals, including iron, are supplied by good pasture, and to some extent by green, leafy alfalfa or other leguminous hay. The amounts supplied vary with the quantity of such feeds consumed as well as with their richness in these nutrients. Yellow corn likewise contains vitamin A, and often makes up a large share of the ration.

## ADDITIONAL CALCIUM NEEDED WHEN MILK IS FED

The solids or dry matter of skimmed milk contains approximately 8.5 per cent of ash or minerals, which is a relatively large amount. Although skimmed milk is comparatively high in calcium, it is not a good corrective of the calcium deficiency of corn or other grains. A ration for pigs should contain from 1 to 2 parts of calcium to 1 of phosphorus. A ratio of 1.5 to 1 probably approaches the optimum. The calcium-phosphorus ratio in milk approximates 1.2:1. The ratio is approximately correct when milk is the sole or chief constituent of the feed, as it is in nature for the young.

From 2 to 3 pounds of skimmed milk to each pound of corn are required to furnish the protein needed by pigs. Such rations contain from 0.56 to 0.67 parts of calcium to 1 of phosphorus. It would take the excessive quantity of 14 pounds of skimmed milk to 1 of corn to give the minimum calcium-phosphorus ratio of 1:1.

Table 1 gives the results of two experiments in which tankage and skimmed milk were compared as supplements to yellow corn for pigs that were confined indoors in pens floored with concrete. The results are summarized in four periods of 5 weeks each.

At first the pigs receiving milk made faster gains and greater gains per unit of feed than those with which they were compared. Later they made a relatively poorer showing. The favorable effects of adding either calcium carbonate or ground alfalfa are shown in the second experiment. As the experiment progressed, four pigs out of five receiving yellow corn and milk died or began to lose rather than gain in weight and, therefore, were removed from the lot. No losses occurred, nor were any removals necessary, in the other lots.

Pulverized limestone is considered a satisfactory source of calcium for pigs. A suggested mineral mixture is one of salt, 19.2; limestone, 38.4; special steamed bone meal or spent bone black, 38.4; powdered ferrous sulfate, 4 parts by weight. Approximately 0.075 to 0.1 pound daily a head should suffice.

TABLE 1.—Skimmed Milk and Tankage as Supplements to Corn

Unless deficiencies are corrected, milk compares less favorably with tankage as time fed increases

	Experiment 1		Experiment 2					
	Shelled corn Tankage	Shelled corn Skimmed milk	Ground corn Tankage	Ground corn Skimmed milk	Ground corn Tankage	Ground corn Skimmed milk Calcium carbonate	Ground corn Tankage	Ground corn Skimmed milk Ground alfalfa
First 5-week period								
Pigs at start.....	5	5	6	5	6	6	6	6
Losses or removals during period.....	0	0	0	0	0	0	0	0
Initial weight per pig, lb.....	55.1	55.3	44.6	49.9	45.0	45.2	45.5	44.9
Average daily gain, lb.....	1.07	1.37	0.42	0.87	0.42	0.91	0.44	1.00
Daily feed per pig, lb.*.....	4.09	4.70	2.10	2.95	1.91	2.98	2.14	2.97
Feed per 100 pounds of gain, lb.*.....	382.62	341.65	497.37	340.08	453.11	328.42	483.87	297.46
Second 5-week period								
Losses or removals during period.....	1	0	0	1	0	0	0	0
Initial weight per pig, lb.....	92.5	103.4	59.4	80.3	59.7	77.0	61.0	79.8
Average daily gain, lb.....	1.38	1.54	0.73	0.25	0.69	1.21	0.62	1.11
Daily feed per pig, lb.*.....	5.58	6.15	2.72	2.58	2.85	4.09	2.75	3.89
Feed per 100 pounds of gain, lb.*.....	404.73	398.40	370.78	1031.45	412.41	338.93	444.62	350.90
Third 5-week period								
Losses or removals during period.....	0	0	0	1	0	0	0	0
Initial weight per pig, lb.....	149.6	157.4	85.1	92.2	83.9	119.2	82.7	118.7
Average daily gain, lb.....	1.43	1.22	0.99	0.15	1.16	1.19	1.01	1.19
Daily feed per pig, lb.*.....	5.79	5.87	3.59	1.70	4.23	4.73	3.73	4.45
Feed per 100 pounds of gain, lb.*.....	390.84	480.87	363.37	1121.65	365.43	396.80	369.34	375.17
Fourth 5-week period								
Losses or removals during period.....	0	1	0	2	0	0	0	0
Initial weight per pig, lb.....	201.5	200.1	119.2	105.0	124.4	161.0	118.0	160.2
Final weight per pig, lb.....	247.0	256.4	159.4	134.0	172.8	196.0	164.7	191.0
Average daily gain, lb.....	1.30	0.87	1.14	0.02	1.38	1.06	1.34	0.99
Daily feed per pig, lb.*.....	6.31	5.63	4.39	1.63	5.09	4.66	4.76	4.66
Feed per 100 pounds of gain, lb.*.....	485.71	653.00	386.16	6840.65	367.64	441.00	366.51	529.20

\*Daily feed and feed per 100 pounds of gain on basis of milk's being reduced to a moisture content of 10 per cent.

The effects of the deficiencies of a corn and milk ration are not as pronounced and do not show up as quickly on older as on younger pigs but, nevertheless, are sometimes observed. In a 15-week test with pigs averaging 79 pounds at the start, those fed corn and tankage made average gains of 1.27, 1.93, and 1.93 pounds daily a head and consumed averages of 333, 356, and 440 pounds of feed per 100 pounds of gain during the three successive 5-week periods. Those fed corn and skimmed milk gained 1.43, 2.02, and 1.45 pounds daily a head and consumed 315, 325, and 505 pounds of feed per 100 pounds of gain during the three periods.

It is not uncommon for pigs that are heavily fed on corn, small grains, or mill feeds, and milk to break down, or become weak, in the pasterns or to show abnormal bone development or other indications of a deficiency of calcium or vitamin D.

### **WORTH OF SKIMMED MILK COMPARED WITH TANKAGE**

Nine trials in which liquid skimmed milk was compared with tankage as a supplement to yellow corn for pigs without pasture are summarized in Table 2.

Ground alfalfa was included in the rations in one, and added minerals, in three of the nine trials. At the prices used for other feeds, and not considering the faster gains, which would have permitted marketing the pigs 17 days earlier, the skimmed milk was worth approximately one-tenth as much a pound as the tankage.

### **LESS VALUABLE FOR PIGS WITH THAN FOR THOSE WITHOUT PASTURE**

Pasture or green feed tends to correct the deficiencies that may exist in a ration, whether it is one containing milk or one containing tankage. In four pasture experiments the differences between both the rapidity of the gains and the amounts of gain made per unit of feed, of the pigs fed tankage and of those fed milk were less than they were in the dry-lot experiments. The average value of the skimmed milk for the pigs on pasture was about one-fourteenth that of tankage a pound.

### **SHOWS GREATER WORTH WHEN FED WITH OTHER HIGH-PROTEIN FEEDS**

For pigs without pasture skimmed milk showed a relatively higher value when it was used to replace only a part rather than all of the tankage or other protein concentrate in the ration. Some of the lots, data for which are reported in Experiment 2 of Table 1, and some of those, 1 to 4 inclusive, data for which are reported in Table 3, were the same. In Table 3 the results are summarized to approximate average final weights of 175 pounds. The pigs that were given approximately a half gallon of skimmed milk daily a head and about half the usual amount of tankage gained at a sufficiently faster rate to enable them to be marketed 3 weeks earlier than those receiving more milk but no tankage.

TABLE 2.—Skimmed Milk and Tankage as Supplements to Corn for Pigs

	In dry lot		On pasture	
	Corn Tankage	Corn Skimmed milk	Corn Tankage	Corn Skimmed milk
Number of trials.....	9	9	4	4
Number of pigs.....	50	50	32	33
Initial weight per pig, lb.....	62	62	62	62
Final weight per pig, lb.....	199	202	191	196
<b>Average daily gain, lb.....</b>	<b>1.24</b>	<b>1.42</b>	<b>1.22</b>	<b>1.26</b>
Days to gain 160 lb.....	130	113	132	127
Daily feed per pig, lb.:				
Corn.....	4.41	4.18	4.44	4.18
Tankage or milk.....	0.44	8.71	0.19	5.60
Ground alfalfa.....	0.02	0.02		
Minerals.....	0.02	0.03		
Total.....	4.89	4.28*	4.63	4.79*
<b>Feed per 100-pound gain, lb.:</b>				
Corn.....	354.93	294.35	362.56	330.76
Tankage or milk.....	35.37	613.02	15.79	443.74
Ground alfalfa.....	1.33	1.07		
Minerals.....	1.78	2.34		
Total.....	<b>393.41</b>	<b>385.94*</b>	<b>378.35</b>	<b>379.57*</b>
Cost of feed per 100-pound gain, dol.....	5.28	5.20	4.84	5.16
Value of milk a pound with tankage at 2.5 cents, ct.....		0.26		0.18
Value of milk a pound with tankage as 100 per cent, pct.....		10.6		7.1

\*With skimmed milk reduced to 10 per cent moisture.

Ground alfalfa was included in the ration in one, and minerals, in three of the nine trials.

Shelled corn, 63 cents a bu.; tankage, \$2.50; skimmed milk, 25 cents; ground alfalfa, \$1.20; minerals, \$2.00; grinding corn, 10 cents a 100 pounds.

Considering only the feed required per unit of gain produced, the skimmed milk, when used in limited quantities and fed along with tankage, was worth about one-sixth as much a pound as tankage. A summary of three trials, including this one, reported in Table 13 of Bulletin 488 showed a somewhat similar average value for skimmed milk when it was fed in this way. The relative worth of the skimmed milk would vary some with changing price relationships between the other feeds, particularly the corn and tankage.

### DRIED SKIMMED MILK

Little or no liquid milk for the pigs is available on many farms. Many creameries, however, have surplus supplies of skimmed milk or buttermilk, particularly at certain seasons of the year. In order to store skimmed milk and lower the cost of transporting it, reducing its moisture content or drying is necessary. Since removing the water is a costly process, such milks are necessarily rather expensive. For this reason a knowledge of the worth of dried milk fed under different conditions is of importance to both the feeder and the producer.

A series of experiments in which different amounts of dried skimmed milk were included in rations of corn, tankage, linseed meal, ground alfalfa, and minerals was carried on in cooperation with the American Dried Milk Institute. Table 4 reports four trials in which dried skimmed milk was fed at a low level and also at a higher level.

TABLE 3.—Comparisons of Skimmed Milk and Tankage, and Their Combination, for Pigs Without Pasture

Pigs fed twice daily	1 Corn Tankage	2 Corn	3 Corn Tankage	4 Corn	5 Corn Tankage
	Ground alfalfa	Skimmed milk Ground alfalfa	Calcium carbonate	Skimmed milk Calcium carbonate	Skimmed milk Calcium carbonate
Number of pigs.....	6	6	6	6	6
Initial weight per pig, lb.....	45.5	44.9	45.0	45.2	45.8
Final weight per pig, lb.....	164.75	172.5	172.8	173.0	177.4
Average daily gain, lb.....	0.85	1.07	0.91	1.07	1.25
Days to gain 160 lb.....	188	150	176	150	128
Daily feed per pig, lb.:					
Ground yellow corn.....	2.97	2.97	3.15	3.18	3.37
Skimmed milk.....		7.22		7.49	4.24
Tankage.....	0.28		0.32		0.16
Ground alfalfa.....	0.10	0.12			
Calcium carbonate.....			0.05	0.06	0.05
Total.....	3.35	3.87*	3.52	4.01*	4.03*
Feed per 100-pound gain, lb.:					
Ground yellow corn.....	348.60	277.22	344.95	293.30	268.56
Skimmed milk.....		673.40		697.59	338.09
Tankage.....	32.48		34.54		12.66
Ground alfalfa.....	11.79	11.55			
Calcium carbonate.....			5.78	5.99	4.28
Total.....	392.87	360.60*	385.27	373.69*	321.56*
Cost of feed per 100-pound gain, dol.....	5.22	5.22	5.20	5.46	4.54
Value of milk a pound with tankage at 2.5 cents, ct.....		0.25		0.21	0.45
Value of milk with tankage as 100 per cent, pct.....		10.0		8.4	18.0

\*With milk reduced to 10 per cent moisture.

Shelled corn, 63 cents a bu; tankage, \$2.50; skimmed milk, 25 cents; ground alfalfa, \$1.20; calcium carbonate, \$2.00; grinding corn, 10 cents a 100 pounds.

Lots 1 to 4, inclusive, are the same as reported in Experiment 2, Table 1, with the data for each summarized to an average final weight of approximately 175 pounds.

The pigs for the experiments were purchased. A few of them were well bred. Most of the others were grades but were of unknown strains or families. On the belief that the milk would show a higher value for young than for older ones, pigs of light weight were secured and were placed on feed as soon after being immunized against cholera as possible. Small pigs do not gain as rapidly as heavier ones.

During the experiments the pigs were confined indoors in pens floored with concrete. Usually under these conditions the faults or advantages of a ration are brought out more quickly and the results are more pronounced than if the pigs are heavier at the start and are kept in outside lots.

Because of its relatively high price dried milk was not tried as the only protein concentrate but was used in small quantities with an effective dry-lot ration. From the feeder's standpoint, there is no particular incentive for the use of a feed unless it can be made to result in an improved product or in greater economy of production than the more effective rations in common use.

Toward the close of the feeding period in the first experiment some of the pigs that had received dried skimmed milk at the higher level became slightly crampy. To avoid a recurrence of this condition a small amount of cod-liver oil was included in all of the rations in the remaining tests.

TABLE 4.—Feeding Dried Skimmed Milk with Corn, the Trio Mixture, and Minerals

	Growing period			Fattening period			Entire time		
	1	2	3	1	2	3	1	2	3
	Yellow corn, tankage, linseed meal, ground alfalfa, minerals, cod-liver oil*								
Dried milk in ration, pct.									
Dried milk in supplement, pct.									
Liquid milk equivalent, daily a head, lb.									
Number of trials	4	4	4	4	4	4	4	4	4
Pigs at start	51	52	53	48	52	51	51	52	53
Initial weight per pig, lb.	38.7	38.5	37.8	113.1	116.3	109.1	38.7	38.5	37.8
Pigs at close	48	52	51	48	52	51	48	52	51
Final weight per pig, lb.	113.1	116.3	109.1	202.2	203.0	202.3	202.2	203.0	202.3
Average daily gain, lb.	0.83	0.85	0.87	1.65	1.62	1.60	1.12	1.13	1.18
Days to gain 160 pounds							143	142	136
Daily feed per pig, lb.:									
Ground corn	2.70	2.67	2.60	5.63	5.43	5.33	3.78	3.69	3.73
Tankage	0.33	0.31	0.26	0.47	0.43	0.34	0.38	0.35	0.29
Linseed meal	0.16	0.15	0.13	0.24	0.21	0.17	0.19	0.18	0.15
Dried skimmed milk									
Ground alfalfa	0.11	0.11	0.10	0.21	0.06	0.25	0.15	0.04	0.20
Minerals	0.04	0.04	0.04	0.09	0.08	0.08	0.06	0.06	0.06
Cod-liver oil	0.01	0.01	0.01	0.02	0.02	0.02	0.01	0.01	0.01
Total	3.35	3.33	3.29	6.66	6.42	6.40	4.57	4.47	4.59
Feed per 100-pound gain, lb.:									
Ground corn	329.74	314.17	297.19	341.95	335.23	332.90	336.34	325.27	316.91
Tankage	39.61	36.37	29.26	28.35	26.54	21.23	33.53	31.19	24.99
Linseed meal	19.80	18.18	14.63	14.18	13.27	10.62	16.76	15.60	12.50
Dried skimmed milk									
Ground alfalfa	13.07	4.10	17.52	12.93	3.71	15.89	13.00	3.89	16.70
Minerals	5.18	12.52	12.04	5.30	12.73	12.90	5.25	12.63	12.52
Cod-liver oil	1.08	4.95	4.77	1.39	4.89	5.05	1.24	4.92	4.92
Total	408.48	391.35	376.41	404.10	397.73	399.88	406.12	394.71	389.71
Cost of feed per 100-pound gain, dol.	5.76	5.70	6.04	5.57	5.63	6.15	5.66	5.66	6.11
Value of dried milk a pound, ct.			4.5		4.3	2.3		5.9	3.3

\*Cod-liver oil was included in the rations in three of the four trials.

Minerals—Salt, 19.2; limestone, 38.4; iron sulfate, 3.97; potassium iodide, 0.03.

Shelled corn, 63 cents a bu.; tankage, \$2.50; linseed meal, \$1.80; dried skimmed milk, \$6.00; ground alfalfa, \$1.20; minerals, \$2.00; grinding corn, 10 cents a 100 pounds; cod-liver oil, 11 cents a pound.

When dried skimmed milk was added, the tankage and linseed meal were reduced so that the total amounts of protein in the various rations were approximately the same. When the pigs averaged from 100 to 125 pounds in weight the protein content of the rations was lowered by decreasing the protein concentrates and increasing the percentage of corn in the rations.

### LIBERAL QUANTITY MORE EFFICIENT BUT LESS ECONOMICAL

At the low level the dried skimmed milk made up approximately 1 per cent of the total feed, or 5 per cent of the supplement. The amount fed was equivalent to approximately  $\frac{1}{8}$  pound of liquid skimmed milk daily a head during the growing period and  $\frac{1}{2}$  pound daily a head during the fattening period. At the higher level the dried milk averaged 4.3 per cent of the total feed and 22.9 per cent of the supplement. This amount was the equivalent of approximately 1.5 pounds of liquid milk daily a head during the growing period and of approximately 2.5 pounds during the fattening period.

Adding dried skimmed milk did not increase the daily feed consumption but did increase the gains produced per unit of feed consumed, particularly during the growing period, or when the pigs were young. It also increased the rapidity of the gains during the growing period. During the fattening period, however, the pigs without the dried milk showed a tendency to make up for their slower gains during the growing period. Consequently, the average rates of gain of the pigs fed no milk and of those fed dried milk at the lower level were practically the same. The pigs fed dried milk at the higher level were ready for market 7 days earlier on the average than those fed no milk.

At the prices used, the other feed saved per unit of gain by the dried milk gave it values, when it was fed at the higher level, of 4.5 and 2.3 cents a pound during the growing and during the fattening periods, respectively. Its average value for the entire time was 3.3 cents a pound. When fed at the lower level the dried milk was worth 7.7 and 4.3 cents a pound during the growing and the fattening periods, respectively. For the entire time its average worth was 5.9 cents a pound.

### MAXIMUM BENEFIT IS FOR YOUNG PIGS

In three of the four tests one group of pigs was fed dried skimmed milk at an intermediate rate of 2.7 per cent of the total feed or 13.4 per cent of the supplement during the growing period but no dried milk during the fattening period. This quantity, for the time it was fed, was the equivalent of approximately 0.8 pound of liquid milk daily a head. The total amount of dried milk given the group was approximately the same as that fed the group given dried milk at the low level for the entire time.

A value somewhat higher than the average of the four tests was obtained for the dried milk, at the same level, in the three tests. Considering only the growing period, dried milk produced faster gains and greater gains per unit of feed but showed a slightly lower replacement value a pound at the intermediate than at the low level. There appeared to be some "carry-over" effect into the fattening period. Therefore, for the entire time, the benefit from feeding the dried milk more liberally while the pigs were young and none later was greater than was that from feeding an equal quantity but using a smaller percentage

TABLE 5.—Medium Amount of Dried Skimmed Milk During First Period Only, Compared with Small Amount and with None for the Entire Time

	Growing period			Fattening period			Entire time		
	1	2	3	1	2	3	1	2	3
	Yellow corn, tankage, linseed meal, ground alfalfa, minerals, cod-liver oil								
	Dried skimmed milk, low level	Dried skimmed milk, medium level	Dried skimmed milk, low level	Dried skimmed milk, low level	Dried skimmed milk, low level	Dried skimmed milk, low level	Dried skimmed milk, low level	Dried skimmed milk, low level	Dried skimmed milk, medium level at first, none later
Dried milk in ration, pct.	1.1	2.7	2.46	5.69	5.39	5.60	3.91	3.74	3.60
Dried milk in supplement, pct.	5.4	13.4	0.27	0.47	0.42	0.47	0.38	0.35	0.34
Liquid milk equivalent, daily a head, lb.	0.33	0.82	0.13	0.24	0.21	0.23	0.19	0.18	0.17
Number of trials	3	3	3	3	3	3	3	3	3
Pigs at start	36	38	34	34	38	33	36	38	38
Initial weight per pig, lb.	39.0	106.3	106.3	106.3	109.4	114.4	39.0	38.9	38.0
Pigs at close	34	36	36	34	38	33	34	38	33
Final weight per pig, lb.	106.3	110.4	110.4	214.7	215.3	211.0	214.7	215.3	211.0
Average daily gain, lb.	0.77	0.94	0.81	1.67	1.62	1.67	1.16*	1.14	1.19*
Days to gain 160 pounds							140	141	135
Daily feed per pig, lb.:									
Ground corn	2.60	2.53	2.46	5.69	5.39	5.60	3.91	3.74	3.60
Tankage	0.32	0.30	0.27	0.47	0.42	0.47	0.38	0.35	0.34
Linseed meal	0.16	0.15	0.13	0.24	0.21	0.23	0.19	0.18	0.17
Dried skimmed milk		0.03	0.08		0.06			0.05	0.05†
Ground alfalfa	0.10	0.10	0.10	0.22	0.21	0.21	0.15	0.14	0.14
Minerals	0.04	0.04	0.04	0.09	0.08	0.09	0.06	0.05	0.06
Cod-liver oil	0.01	0.01	0.01	0.03	0.03	0.03	0.02	0.02	0.02
Total	3.23	3.16	3.09	6.74	6.40	6.62	4.71	4.53	4.38
Feed per 100-pound gain, lb.:									
Ground corn	338.18	320.09	302.34	340.78	332.04	335.60	339.77	327.02	320.38
Tankage	40.91	37.30	32.68	28.43	25.14	27.89	33.26	30.76	30.09
Linseed meal	20.45	18.65	16.34	14.21	13.07	13.94	16.63	15.38	15.04
Dried skimmed milk		4.27	10.39		3.73			3.95	4.76†
Ground alfalfa	13.43	12.78	12.16	12.90	12.60	12.70	13.10	12.68	12.45
Minerals	5.04	4.79	4.56	5.23	4.73	5.16	5.16	4.75	4.88
Cod-liver oil	1.62	1.52	1.61	1.61	1.58	1.59	1.58	1.58	1.56
Total	419.69	399.48	379.99	403.16	393.89	396.88	409.56	396.12	388.16
Cost of feed per 100-pound gain, dol.	5.98	5.87	5.84	5.58	5.60	5.49	5.73	5.71	5.65
Value of dried milk a pound, ct.		8.6	7.3		5.4			6.6	7.7

\*Of the pigs remaining in the groups at the close of the test. With the gains (previous to the time they were removed) of the Lot 2 and 5 pigs that were taken out included, the average daily gains for Lots 1 and 3 were 1.15 and 1.12 pounds, respectively. No pigs were removed from Lot 2.

†Average for entire time, but was fed during the growing period only.

Mineral mixture and feed prices same as given in footnotes under Table 3.

at first and continuing its use through the later period as well. A 16.7 per cent greater value was obtained for the dried milk by the first than by the second plan.

Computed on a basis of the data for the four tests, the value of the dried milk when used only while the pigs were young was 6.9 cents a pound, as compared with the values of 5.9 cents and 3.3 cents a pound obtained for it when it was fed for the entire time at the low and higher levels, respectively.

At any of the rates at which it was fed, dried skimmed milk showed a higher value per pound of protein contained than tankage. It did not pay to feed the dried milk to young pigs at the relatively high level of 24 per cent of the supplement. Nor, at the levels tried and at a price exceeding 5.4 cents a pound, did it pay to use the dried milk during the latter part of the feeding period. At prevalent prices, including from 5 to 12 per cent of dried skimmed milk in a supplement of tankage, linseed meal, ground alfalfa, minerals, and cod-liver oil for young pigs having no pasture was economical.

# FEED SALES IN OHIO

J. I. FALCONER

Since 1929 the Department of Rural Economics has received annually from feed manufacturers a report of their feed sales in Ohio. A compilation of the results of this study for 1937 and earlier years is given in Table 1. It will be noted that the total sales for 1937 were 2.9 per cent above those of 1936, and the largest of any year since 1930.

**TABLE 1.—Estimated Tons of Commercial Feeds Reaching the Retail Trade in Ohio, 1929-1937**

Feed	Estimated tons					
	1929	1932	1933	1935	1936	1937
<b>MIXED FEEDS:</b>						
Dairy feeds .....	128,320	25,214	30,181	40,345	61,817	73,030
Poultry feeds .....	189,139	56,805	68,754	98,489	154,213	145,885
Hog feeds .....	36,758	2,898	6,092	13,901	28,740	42,946
Other mixed feeds .....	24,728	13,332	17,028	16,782	22,838	23,904
Total mixed feeds .....	378,945	98,249	122,055	169,517	267,608	285,765
<b>UNMIXED FEEDS:</b>						
Soybean meal* .....			5,206	20,986	24,287	22,297
Cottonseed meal .....	16,708	6,666	8,425	9,648	11,960	11,461
Linseed oil meal .....	24,060	17,099	19,850	16,033	10,580	10,254
Bran .....	59,167	55,066	57,159	43,419	41,299	40,493
Middlings .....	56,431	42,024	55,015	45,831	45,736	52,966
Alfalfa meal .....	4,762	5,507	2,802	3,142	3,877	4,349
Gluten feeds .....	20,257	15,650	21,222	13,267	13,725	14,949
Hominy .....	49,775	11,303	29,517	22,915	20,342	12,443
Tankage .....	8,971	10,434	10,581	10,444	12,206	12,910
Meat scraps .....	12,154	17,389	20,412	23,639	24,780	25,154
Fish meal† .....					673	817
Milk products .....	1,736	1,739	3,069	2,950	3,577	3,984
All other feeds .....	35,367	8,695	14,278	28,946	33,903	31,946
Total unmixed feeds ..	289,388	191,572	247,536	241,220	246,945	244,023
<b>TOTAL (all feeds) .....</b>	<b>668,333</b>	<b>289,821</b>	<b>369,591</b>	<b>410,737</b>	<b>514,553</b>	<b>529,788</b>

\*No report previous to 1933.

†No report previous to 1936.

**TABLE 2.—Annual Feeds Sales in Ohio**

Year	Total tonnage	Year	Total tonnage
1929 .....	668,333	1934 .....	371,439
1930 .....	566,079	1935 .....	410,737
1931 .....	410,104	1936 .....	514,553
1932 .....	289,821	1937 .....	529,788
1933 .....	369,591		

## EARLY FRUIT THINNING IN RELATION TO ANNUAL BEARING

FREEMAN S. HOWLETT AND THOMAS F. FOWLER

There is a feeling that the orchard business would rest upon a more profitable foundation if the peaks and troughs of production could be made less prominent, if not entirely obliterated. Some growers have the opinion that only as this can be accomplished will the disastrous effects of high yields, such as occurred in 1937, be reduced.

Individual growers point to frequent instances in which a loss could have been turned into profit if the yields from certain varieties had been carried over from a heavy to a lighter bearing year. This has been true not only with varieties which have a pronounced tendency to alternate bearing but also with certain trees of varieties which have a more or less regular bearing habit. This latter group includes the varieties Grimes Golden, Golden Delicious, Jonathan, McIntosh, Northern Spy, and even Stayman Winesap. No procedure invariably capable of changing a "tree" or a "variety" from an alternate to an annual bearing condition has ever been generally recommended. To be sure, removal of flowers will change the year of alternation, but obviously, if complete, it cannot produce annual bearing. Furthermore, no single recommended procedure has been found to be productive of dependable results.

Several factors are responsible for the tendency toward alternate bearing. It has become evident that the variety factor is exceedingly important, and as a result, some horticulturists have come to feel that the best approach to the problem is the selection of annual bearing varieties. In addition, the exhaustiveness of fruiting has been found important in inducing alternate bearing. As a matter of fact, it is of sufficient importance to cause even the supposedly annual bearing trees to bear flowers alternately, and the results presented in this paper are largely concerned with trees of these more or less annual varieties which for a number of years had been bearing alternately. It is thus obvious that the observed response of a tree is the result of the variety factor and the food exhaustion factor working together. Even among the annual bearing varieties the alternate bearing condition will develop if fruiting is too exhaustive of the resources of the tree.

It is not an easy matter to alleviate this exhaustiveness. It is easier to maintain a tree in the annual bearing condition than to change it from the alternate to the annual bearing state. Suggestions have been made in regard to the latter procedure but return to the annual condition has not invariably resulted when theoretical suggestions have been carried out.

In view of this fact the effect of early and late thinning of fruits has received considerable study by Magness and his associates (1) in the United States Department of Agriculture. They have obtained a very favorable response from a heavy, early thinning in producing flowers for the succeeding year's crop. The time of thinning most effective in bringing about this response was found to be up to 4 weeks from full bloom, before the June drop had been completed in case it had started. Furthermore, the thinning was sufficiently heavy to give only 1 fruit to 100 leaves in the year of this early

1. Magness, J. R., L. A. Fletcher, and W. W. Aldrich. 1934. Time during which fruit bud formation may be influenced in the Shenandoah Cumberland fruit districts. *Proc. Amer. Soc. Hort. Sci.* 30: 313-318.

thinning. Obviously this gives considerably less than a commercial crop during that year. It is also obvious that the grower cannot determine the number of leaves and fruits on a tree without such difficulty as to make the recommendation on this basis impracticable. The varieties which gave this favorable response were not only more or less annual in bearing, but some were decidedly alternate in their flowering as well. The first included the varieties Delicious, Jonathan, Rome Beauty, and Stayman Winesap. In the latter group were Oldenburg, Yellow Transparent, and York Imperial.

Little evidence is available to indicate the largest amount of fruit that may be left on a tree at this early thinning in order to permit the development of sufficient flowers to give a full commercial crop the succeeding year. The above-mentioned investigators used no lower fruit to leaf ratio than 1 fruit to 100 leaves. Potter (2) in New Hampshire thinned a McIntosh tree which was in an alternate bearing condition to 1 fruit to 50 leaves 3 to 6 weeks after blossoming. As a result of thinning at the 3-week interval, 25 per cent of the spurs formed flowers—sufficient for a full commercial crop the succeeding year. The thinning did reduce the total yield, but the extent of the reduction below a full commercial crop due to this early thinning was not given. He concluded that unless thinning is done early it should be omitted, and recommended thinning 3 weeks after blossoming in New Hampshire for alternate bearing McIntosh trees. Brown (3) in Oregon presented the data in a manner which can be more easily interpreted from a practical viewpoint. He thinned alternating Yellow Newtown trees heavily (one fruit to 10 to 12 inches) and lightly (one fruit to 6 inches) 30 days after full bloom. The trees had flowered heavily the year of thinning (1933) and the reduction in yield by the heavy thinning was approximately 25 per cent. Increased size of the fruits compensated in part for this reduction. The following year there was less than a bushel of fruit on the tree thinned lightly in 1933, but there were 14 bushels on the tree which had been thinned heavily. The trees had the same total yield over the 2-year period. Because of the greater yield on the lightly thinned tree in 1933 the returns were 7 dollars greater. On the other hand, the 14-bushel gain the succeeding year would still more than offset the added cost of the heavier thinning the year previous.

### PURPOSE OF THE THINNING EXPERIMENTS REPORTED

The purpose of the thinning experiments reported herein was to determine more definitely than the above investigations indicated, the extent of early fruit thinning which would permit the development of sufficient flowers for a full commercial crop the subsequent year and yet not greatly reduce the crop the year of thinning. It is to be recalled that the results of the afore-mentioned investigators were largely expressed on the basis of fruits to leaves. Furthermore, the branches in several instances had been ringed, and these ringed branches were not quite comparable to unringed limbs. The early thinning was thus designed to give data more readily applicable to practice in the orchard. Because of the small number of trees available, only one degree of thinning was used, one fruit cluster (containing one fruit only) to four original flower clusters. On the basis of five flowers per cluster, this represented the

2. Potter, George F. 1937. Biennial bearing in McIntosh. *Proc. Amer. Soc. Hort. Sci.* 34: 139-142.

3. Brown, Gordon G. 1935. Bulk fruit thinning and wide spacing of Newtown apples. *Proc. Amer. Soc. Hort. Sci.* 32: 47-49.

development of 5 per cent of the flowers into fruits. It has been stated by some that this percentage of flowers developing into fruits will give a full commercial crop. However, the writer has obtained much data which indicate that a greater percentage of the flowers must usually set fruit if a full commercial crop is to be obtained. This fact obviously depends upon the variety and the abundance of the bloom, that is, flower clusters to leaf clusters. The thinning was carried out uniformly because of the uniform bloom and fruit setting.

### PLAN OF THE EXPERIMENT

Trees were selected which had been bearing alternately for 14 to 15 years as is indicated by Table 1. Varieties included were Delicious, Northern Spy, Oldenburg, and Stayman Winesap. The trees were growing in the orchards of the Ohio Agricultural Experiment Station at Wooster. They had received annually a light thinning-out pruning and an application of a readily available nitrogen-carrying fertilizer.

TABLE 1.—Annual Yields, from 1920 to 1937 Inclusive, of Trees Used in Early Thinning Experiments

Year	Delicious Trees 406-10	Duchess Tree 402	Northern Spy Tree 178	Stayman Winesap Tree 426	Stayman Winesap Tree 622
	<i>Bu.</i>	<i>Bu.</i>	<i>Bu.</i>	<i>Bu.</i>	<i>Bu.</i>
1920.....	7.7	5.8	11.2	1.0	
1921.....	8.4	0.0	48.5	18.3	
1922.....	11.7	6.1	9.5	12.7	
1923.....	19.5	0.8	52.5	12.5	
1924.....	7.0	10.6	1.1	14.4	
1925.....	18.0	0.8	38.6	17.1	
1926.....	2.7	10.9	0.0	18.9	
1927.....	13.1	0.0	50.9	9.5	
1928.....	0.3	11.8	15.5	1.1	
1929.....	15.8	7.5	48.3	14.6	
1930.....	1.3	3.5	0.1	6.5	
1931.....	25.0	20.6	58.3	20.0	
1932.....	0.1	2.1	9.8	2.5	
1933.....	17.8	19.2	53.8	16.0	
1934.....	8.9	0.2	0.3	1.1	
1935.....	17.0	22.8	44.8	17.9	
1936.....	6.7	7.2	22.0	11.0	
1937.....	22.2	19.3	40.5	25.4	

Each tree was divided into halves as far as possible using the large scaffold limbs. Each scaffold received only one type of thinning. The early thinning was carried out approximately 3 weeks after petal fall; whereas the late thinning was done 3 to 4 weeks later, at the time when thinning is usually carried out. The early thinning was designed to leave one fruit cluster to form four flower clusters; whereas in the late thinning the fruit clusters (also containing one fruit each) were uniformly spaced 8 to 10 inches apart. This late thinning was comparable in spacing to that carried out ordinarily throughout the orchards. All trees used had abundant bloom in 1935.

The ratio of the number of fruit clusters to leaf clusters on the late thinned limbs after thinning was taken as the *index* of a full commercial crop. In order to obtain quantitative data, all flower clusters<sup>1</sup>, leaf clusters<sup>1</sup>, and fruit clusters were counted on representative limbs on each half of the tree before and after thinning. Only large, vigorous leaf and flower clusters were counted. This type of data permitted an expression of the amount of bloom as the ratio of flower clusters to leaf clusters; of the amount of set as the ratio of fruit clusters to flower clusters; and of the relative fruiting as the ratio of fruit clusters to leaf clusters. In 1936 and 1937 similar data were taken in order to place these results also on a quantitative basis. In these years the count of fruit set was taken after the so-called June drop.

## PRESENTATION OF THE DATA

### VARIETY DELICIOUS

The tree used had an abundant bloom, and the early thinning was found to have left one fruit cluster to four and six-tenths leaf clusters, which corresponded to 4.0 per cent set (Table 2). The late thinning resulted in one fruit cluster to three and two-tenths flower clusters (5.6 per cent set), which corresponded to one fruit cluster to five and six-tenths leaf clusters. When this latter ratio was used as the index of a full commercial crop, the ratio of one fruit cluster to seven and eight-tenths leaf clusters on the early thinned half represented a crop reduction of 30 per cent. However, the fruits at maturity on this half were 19 per cent larger (Table 7), and this larger size increased the actual yield on the early thinned half to 83 per cent of a full commercial crop despite the heavy thinning.

TABLE 2.—Effect of Early and Late Thinning in 1935 on Subsequent Flower Formation, 1935-1937

Variety Delicious

Early thinning June 3, 1935. Late thinning June 20, 1935

Time of thinning in 1935	Ratio of flower clusters to leaf clusters			Ratio of fruit clusters to flower clusters			Ratio of fruit clusters to leaf clusters			Approximate percentage of full commercial crop (1 fruit to 5.4 leaf clusters as 100)		
	1935	1936	1937	1935*	1936	1937	1935*	1936	1937	1935*	1936	1937
Early												
Branch 1 .....		1: 3.8	1: 4.0	.....	1: 1.5	1: 2.1	.....	1: 5.5	1: 8.3	.....	.....	.....
Branch 2 .....		1: 3.3	1: 1.3	.....	1: 1.0	1: 5.4	.....	1: 3.5	1: 7.0	.....	.....	.....
Average...	1:1.7	1: 3.7	1: 2.2	1:4.6	1: 1.3	1: 3.5	1:7.8	1: 4.9	1: 7.8	70	110	70
Late												
Branch 1 .....		1:10.2	1: 2.9	.....	1: 1.5	1: 6.4	.....	1:15.0	1:17.1	.....	.....	.....
Branch 2 .....		1: 8.6	1: 1.7	.....	1: 1.3	1: 2.2	.....	1:11.4	1: 3.8	.....	.....	.....
Average...	1:1.7	1: 9.7	1: 2.2	1:3.2	1: 1.4	1: 3.1	1:5.4	1:13.8	1: 6.8	100	39	80

\*After thinning in 1935.

Percentage of flowers setting fruit before thinning in 1935, 7.8.

Percentage of flowers setting fruit after early thinning in 1935, 4.0.

Percentage of flowers setting fruit after late thinning in 1935, 5.6.

<sup>1</sup>Since the apple flower cluster has developed from a "mixed" bud, that is, the flower cluster also contains leaves, the number of leaf clusters also includes the flower clusters. Thus, for example, a ratio of one flower cluster to one and five-tenths leaf clusters means 100 of the 150 leaf clusters have flowers.

In 1936 the bloom on the portion of the tree thinned late in 1935 was very light; there was only one flower cluster to nine and seven-tenths leaf clusters (Table 2). On the other hand, on the early thinned half there was one flower cluster to three and seven-tenths leaf clusters. After all dropping had ceased, the ratio of fruit clusters to leaf clusters on the portion thinned early in 1935 was 1 to 4.9 as compared to 1 to 13.8 on the late thinned portion. When the 1935 index of a full crop (one fruit cluster to five and six-tenths leaf clusters) was used, the yield on the portion thinned early in 1935 was 10 per cent more than a full crop. On the other hand, the late thinned half had only 39 per cent of a crop. Actually, the crop on this portion was considerably less, since the bloom had not been uniform and the counts had been taken from the limbs with the greater number of flower clusters.

In 1937 the flowering was abundant on both portions of the tree; there was no difference between the two halves despite the difference in yield in 1936 (Table 2). The set was not nearly so good as in 1936, as is indicated by the fact that after dropping had ceased there was one fruit cluster to three and one-tenth to three and five-tenths flower clusters. Because of this the yield on both halves (figured by the same ratio of fruit to leaf clusters as in 1935 and 1936) was slightly less than a full commercial yield. This situation might not prove unsatisfactory if it resulted in a moderate flower formation for the 1938 crop<sup>2</sup>.

#### VARIETY NORTHERN SPY

The tree had an abundant bloom, and after the early thinning one fruit cluster was found to be present to four and four-tenths flower clusters (4.1 per cent set) and seven and six-tenths leaf clusters (Table 3). After the late thinning one fruit cluster was present to two and two-tenths flower clusters (8.3 per cent set) and four leaf clusters. Using the latter ratio as an index of a full commercial crop makes the reduction in yield by the early thinning 47 per cent. However, the 27 per cent increase in size of fruits (Table 7) as a result of the early thinning brought the actual yield on the early thinned portion up to 67 per cent of a full commercial crop.

In 1936 both portions had practically the same amount of bloom, but actually it was approximately half the amount borne the previous year (Table 3). The interesting fact developed that the portion of the tree which bore the full crop in 1935 had a considerably heavier drop. After all dropping had ceased the portion of the tree thinned early in 1935 had one fruit cluster to one and five-tenths flower clusters as compared to one fruit cluster to two and four-tenths flower clusters on the late thinned half. Apparently the heavy crop in 1935 had resulted in some exhaustion of food materials. In consequence of this heavier drop on the late thinned half, one fruit cluster was present to seven and six-tenths leaf clusters as compared with a ratio of 1 to 4.9 on the early thinned half. On the early thinned half this was equivalent to 82 per cent of a full commercial crop as compared with 53 per cent of a full crop on the late thinned half.

In 1937 the bloom on the portion with the heavier crop in 1936 was rather satisfactory but actually only half of that on the portion bearing the lighter yield. On the latter portion (late thinned in 1936) the ratio of flower clusters to leaf clusters was 1 to 2, or nearly as abundant as in 1935. The percentage

<sup>2</sup>The flowering in 1938 on both halves of this tree was very light.

of flowers developing into fruits was nearly the same on both portions. The proportion of fruit clusters to leaf clusters on the two halves was equivalent to 143 per cent on the heavy flowering portion and to 78 per cent on the lighter flowering portion, which had been thinned early in 1935.

**TABLE 3.—Effect of Early and Late Thinning in 1935 on Subsequent Flower Production, 1935-1937**

Variety Northern Spy

Early thinning June 3, 1935. Late thinning late June, 1935

Time of thinning in 1935	Ratio of flower clusters to leaf clusters			Ratio of fruit clusters to flower clusters			Ratio of fruit clusters to leaf clusters			Approximate percentage of full commercial crop (1 fruit to 4 leaf clusters as 100)		
	1935	1936	1937	1935*	1936	1937	1935*	1936	1937	1935*	1936	1937
<b>Early</b>												
Branch 1 .....	1: 3.3	1: 4.1	.....	1: 1.4	1: 1.6	.....	1: 4.6	1: 6.7	.....	.....	.....	.....
Branch 2 .....	1: 3.4	1: 3.9	.....	1: 1.7	1: 1.1	.....	1: 5.9	1: 4.4	.....	.....	.....	.....
Average...	1:1.7	1: 3.3	1: 4.0	1:4.4	1: 1.5	1: 1.3	1:7.6	1: 4.9	1: 5.1	53	82	78
<b>Late</b>												
Branch 1 .....	1: 9.6	1: 2.2	.....	1: 1.0	1: 1.3	.....	1: 9.6	1: 3.0	.....	.....	.....	.....
Branch 2 .....	1: 2.0	1: 1.8	.....	1: 3.2	1: 1.5	.....	1: 6.6	1: 2.7	.....	.....	.....	.....
Average...	1:1.8	1: 3.2	1: 2.0	1:2.2	1: 2.4	1: 1.4	1:4.0	1: 7.6	1: 2.8	100	53	143

\*After thinning in 1935.

Percentage of flowers setting fruit before thinning in 1935, 17.3.

Percentage of flowers setting fruit after early thinning in 1935, 4.1.

Percentage of flowers setting fruit after late thinning in 1935, 8.3.

### VARIETY OLDENBURG

The Oldenburg tree bloomed heavily in 1935, and after the early thinning on May 25 there was one fruit cluster to four and four-tenths flower clusters, corresponding to 4.1 per cent of the flowers developing into fruits (Table 4). Unfortunately, no record is available of the number of fruit clusters remaining after the late thinning. There was undoubtedly some reduction in yield by the early thinning, but the fruits were larger, and size again in part compensated for the smaller number of fruits.

In 1936 the bloom on the half thinned early in 1935 was very heavy (Table 4). This bloom was nearly as heavy as that of the year previous and was equivalent after all dropping had ceased to one fruit cluster to three and one-tenth leaf clusters. The bloom on the half thinned late in 1935 was light with one flower cluster to seven and six-tenths leaf clusters. As indicated by the relative fruit to leaf ratios, the crop on the light blooming portion was less than a third that on the heavy blooming portion, which had been thinned early in 1935. As a matter of fact, there was actually a greater difference between the two portions, since the counts of bloom and fruit set were taken from the branches on the late thinned side which had the most flower clusters, but upon which the bloom was very light and irregular.

In 1937 the amounts of bloom on the two halves were reversed as compared with those of 1936. The bloom was heavy on the lighter blooming portion in 1936; whereas on the heavy bearing portion of 1936, although still appreciable, it was only half as abundant. There was a slightly greater percentage of the

flowers setting fruit on this lighter blooming portion. If one fruit cluster to three leaf clusters is arbitrarily taken as a full commercial yield, the crop on the lighter blooming half would be only 30 per cent less than a full crop.

**TABLE 4.—Effect of Early and Late Thinning in 1935 upon Subsequent Flower Formation, 1935 to 1937**

Variety Oldenburg

Early thinning May 25, 1935. Late thinning June 18, 1935

Time of thinning in 1935	Ratio of flower clusters to leaf clusters			Ratio of fruit clusters to flower clusters			Ratio of fruit clusters to leaf clusters		
	1935	1936	1937	1935*	1936	1937	1935*	1936	1937
Early									
Branch 1 .....		1: 1.9	1: 2.9		1: 1.6	1: 1.8		1: 3.1	1: 5.1
Branch 2 .....		1: 1.9	1: 1.7		1: 1.7	1: 2.4		1: 3.2	1: 4.1
Average.....	1: 1.3	1: 1.9	1: 2.3	1: 4.4	1: 1.7	1: 2.0	1: 5.8	1: 3.1	1: 4.7
Late									
Branch 1 .....			1: 1.0			1: 2.5			1: 2.6
Branch 2 .....			1: 1.3			1: 2.1			1: 2.7
Average.....	1: 1.3	1: 7.6	1: 1.2		1: 1.3	1: 2.3		1:10.2	1: 2.6

\*After thinning in 1935.

Percentage of flowers setting fruit after early thinning in 1935. 4.2.

#### VARIETY STAYMAN WINESAP

Two trees of Stayman Winesap were used for the thinning tests. Both trees had more than the usual number of flowers. Full bloom occurred on May 9 and petal fall, on May 13.

#### TREE 426

This tree bloomed heavily in 1935. The early thinning was found to be more severe than had been desired, since the ratio after thinning was one fruit cluster to five and four-tenths flower clusters (Table 5). On the other hand, after the late thinning to a spacing of 8 inches, the comparable ratio was 1 to 3. The ratio of one fruit cluster to four and five-tenths leaf clusters on this portion of the tree was taken as the index of a full commercial crop. On this basis the early thinning had reduced the crop 44 per cent. At harvest it was found that the fruits on this portion of the tree were 28 per cent larger (Table 7). This increased the yield to the extent that finally only a 28 per cent reduction was brought about by the early thinning.

In 1936 the bloom was heavy on the early thinned portion and fairly light on the late thinned portion. After all dropping had ceased, the crop on the early thinned half (on the 1935 basis of one fruit cluster to four and five-tenths leaf clusters as 100) was 102 per cent of a full crop. On the other hand, there was only half a full crop on the late thinned half. The increased size, due to the smaller number, of the fruits on this portion of the tree raised the yield appreciably, as occurred in 1935 on the early thinned portion. It is also evident that although the fruits on the early thinned portion had been spread over the 2-year period, there was no increase in total yield of the early thinned over the late thinned portion.

In 1937 both portions of the tree responded with a heavy bloom and fruit set. In consequence, after all dropping had ceased the crop was equivalent to 144 to 150 per cent of a full crop on the basis of one fruit cluster to four and five-tenths leaf clusters as a full commercial crop.

**TABLE 5.—Effect of Early and Late Thinning in 1935 upon Subsequent Flower Formation, 1935 to 1937**

Variety Stayman Winesap—Tree 426

Early thinning May 28, 1935. Late thinning June 25, 1935

Time of thinning in 1935	Ratio of flower clusters to leaf clusters			Ratio of fruit clusters to flower clusters			Ratio of fruit clusters to leaf clusters			Approximate percentage of full commercial crop (1 fruit to 4.5 leaf clusters as 100)		
	1935	1936	1937	1935*	1936	1937	1935*	1936	1937	1935*	1936	1937
Early												
Branch 1 .....		1: 3.2	1: 1.7	.....	1: 1.7	1: 2.7	.....	1: 5.3	1: 4.6	.....	.....	.....
Branch 2 .....		1: 2.0	1: 1.6	.....	1: 1.8	1: 1.4	.....	1: 3.7	1: 2.2	.....	.....	.....
Average....	1:1.5	1: 2.5	1: 1.7	1:5.4	1: 1.8	1: 1.9	1:8.1	1: 4.4	1: 3.1	56	102	144
Late												
Branch 1 .....		1: 6.0	1: 2.0	.....	1: 1.3	1: 1.8	.....	1: 7.9	1: 3.5	.....	.....	.....
Branch 2 .....		1:12.0	1: 1.1	.....	1: 1.0	1: 2.2	.....	1:12.0	1: 2.5	.....	.....	.....
Average....	1:1.5	1: 7.4	1: 1.5	1:3.0	1: 1.2	1: 2.0	1:4.5	1: 8.8	1: 3.0	100	51	150

\* After thinning in 1935.

Percentage of flowers setting fruit before thinning in 1935, 8.7.

Percentage of flowers setting fruit after early thinning in 1935, 3.4.

Percentage of flowers setting fruit after late thinning in 1935, 6.0.

#### TREE 622

This tree had an exceptionally heavy bloom. After the early thinning there was one fruit cluster to four and four-tenths flower clusters; whereas after the late thinning to a spacing of 8 inches the equivalent ratio was 1 to 3.8 (Table 6). This represented on the late thinned portion one fruit cluster to five and three-tenths leaf clusters, which is taken as the index of a full commercial crop. On this basis the reduction in yield by early thinning was only 12 per cent. The data in Table 7 show that the fruits were 12 per cent larger at maturity on this portion of the tree. This would be sufficient to bring the yield up to practically a full commercial crop on the early thinned portion despite the heavier thinning.

In 1936 the bloom was heavy on the half thinned early in 1935 and fairly light on the late thinned portion (Table 6). The ratio of fruit clusters to leaf clusters after all dropping had ceased on the early thinned half was 1 to 4.4; on the half thinned late, 1 to 11.0. On the basis of a full crop as a ratio of one fruit cluster to five and three-tenths leaf clusters, the yield on the early thinned portion would be 120 per cent of a full commercial yield as compared to practically half a full crop on the late thinned half. In the latter case the larger size of the fruits would compensate in part for the smaller number.

In 1937 the bloom was nearly similar on both halves and about as heavy as in 1935 (Table 6). Following an equally heavy set there were one fruit cluster to three and one-tenth leaf clusters on the half thinned early in 1935 (the heavy bearing side in 1936) and one fruit cluster to three and three-tenths leaf clusters on the late thinned half. This was equivalent on both portions to considerably more than a full commercial crop.

The data on this tree differ from those obtained from the other trees in showing an actual increase in production over the 2-year period for the half thinned early in 1935, because in 1935 there was produced a full crop despite the heavier thinning.

**TABLE 6.—Effect of Early and Late Thinning in 1935 upon Subsequent Flower Formation, 1935 to 1937**

Variety Stayman Winesap—Tree 622

Early thinning June 3, 1935. Late thinning June 25, 1935

Time of thinning in 1935	Ratio of flower clusters to leaf clusters			Ratio of fruit clusters to flower clusters			Ratio of fruit clusters to leaf clusters			Approximate percentage of full commercial crop (1 fruit to 5.3 leaf clusters as 100)		
	1935	1936	1937	1935*	1936	1937	1935*	1936	1937	1935*	1936	1937
Early												
Branch 1 .....	1: 3.2	1: 1.2	.....	1: 1.4	1: 3.6	.....	1: 4.6	1: 4.3	.....	.....	.....	.....
Branch 2 .....	1: 2.1	1: 1.7	.....	1: 2.0	1: 1.7	.....	1: 4.3	1: 2.9	.....	.....	.....	.....
Average...	1:1.4	1: 2.7	1: 1.6	1:4.2	1: 1.6	1: 2.0	1:6.0	1: 4.4	1: 3.1	88	120	167
Late												
Branch 1 .....	1:10.0	1: 1.4	.....	1: 1.4	1: 2.3	.....	1:14.0	1: 3.4	.....	.....	.....	.....
Branch 2 .....	1: 5.6	1: 1.3	.....	1: 1.5	1: 2.5	.....	1: 8.4	1: 3.2	.....	.....	.....	.....
Average...	1:1.4	1: 7.5	1: 1.3	1:3.8	1: 1.5	1: 2.4	1:5.3	1:11.0	1: 3.3	100	48	160

\*After thinning in 1935.

Percentage of flowers setting fruit before thinning in 1935, 8.9.

Percentage of flowers setting fruit after early thinning in 1935, 4.4.

Percentage of flowers setting fruit after late thinning in 1935, 4.8.

## DISCUSSION

The results show that the early thinning (1935) permitted the production of sufficient flowers to give a full commercial crop of fruit the subsequent year. On the other hand, the thinning carried out at the usual time (after the so-called June drop) was associated with a very large reduction in fruit the following year. On the basis of fruit clusters to flower clusters, the crop in 1936 on the half thinned late in 1935 was in general equivalent to about 40 to 50 per cent of a full commercial yield. This response was obtained with all varieties used in the experiment, namely, Delicious, Northern Spy, Oldenburg, and Stayman Winesap. Although of these varieties only Oldenburg would be classed as a variety possessing a pronounced tendency toward alternate bearing, yet the trees of the other varieties had been bearing alternately for 10 to 15 years.

This heavy production of flowers for the 1936 crop on the early thinned portions was obtained in spite of the fact that nearly 25 per cent of the flower clusters were permitted to hold one fruit to maturity during 1935. This represented 4 to 5 per cent of the flowers developing into mature fruits. This ratio of one fruit cluster to four flower clusters is equivalent to a much lower fruit to leaf ratio than the 1 to 100 used in the experiments of Magness and his associates (1). The results verify the conclusion of these investigators that an early thinning carried out within 3 to 4 weeks after petal fall permits sufficient flower production for a full crop the subsequent year.

It is of special importance to note the extent of the crop reduction the year of the early thinning. The data in Tables 2 to 6 show that on the basis of fruit to leaf clusters the reduction in yield below a full commercial crop on the early thinned portion was equivalent to 12 to 47 per cent. However, in all instances the fruit on the early thinned trees was of larger size (Table 7). This increased size compensated for the smaller number of fruits to the extent that there was no crop reduction due to the early thinning on Stayman Winesap Tree 622, and on the trees of the other varieties the reduction in yield varied from 19 to 33 per cent. This indicates that there was at least two-thirds of a full commercial yield despite the heavy thinning.

TABLE 7.—Size of Fruit in Relation to Time of Thinning, 1935

Variety	Tree number	Treatment	Number of fruits	Weight of fruits		Percentage of fruit with diameter given below		
				Total pounds	Per fruit, ounces	2½ in.	2¼-2½ in.	2¼ in.
Delicious.....	406-10	Early thinning	880	329	5.98	87.9	12.1	0
		Late thinning	1306	412	5.05	85.5	14.5	0
Delicious.....	452	Early thinning	593	252	6.80	95.4	4.6	0
		Late thinning	1615	570	5.03	89.3	10.5	0
Northern Spy.	178	Early thinning	1776	930	8.37	99.3	0.7	0
		Late thinning	2701	1108	6.56	92.9	6.9	0.2
Stayman Winesap.....	426	Early thinning	755	280	5.93	{ No size	grade	
		Late thinning	1658	482	4.65			
Stayman Winesap.....	622	Early thinning	336	133	6.33	96.4	3.6	0
		Late thinning	337	121	5.74	94.7	5.3	0

Furthermore, it is to be especially noted that in general the early thinning did not give a greater yield over the 3-year period than was obtained from the late thinned portions. The one exception was Stayman Winesap Tree 622. In this instance, the yield over the 3-year period was significantly greater on the portion thinned early in 1935. However, it would be unwise for a grower to expect other than a more favorable distribution of yield over the period as a response to early thinning. This is verified by the thinning experiment of Brown (2) in Oregon.

In 1937, despite the difference in yield on the two halves in 1936, about the same bloom and yield were produced. As a consequence, it was evident that the trees had again approached the situation occurring in 1935 when a heavy bloom had been produced. It is not known at present whether these trees will go into an alternating condition again or will bear crops more or less annually<sup>a</sup>.

The practicability of an early thinning in commercial practice for the purpose of modifying an alternate bearing condition obviously depends upon several factors, some of which are economic in nature. Insofar as they are of economic nature they are not within the control of the individual grower. For example, early thinning involves a greater expenditure of time than late thinning. Thus, the added cost depends upon existing wage scales. The actual

<sup>a</sup>In 1938 the bloom on the Oldenburg tree used in this experiment was heavy on the greater part of the tree with the light crop in 1937 (portion thinned early in 1935). The bloom in 1938 on Stayman Winesap Tree 622 was very scattered as might have been predicted because of the heavy yield in 1937. The bloom on the Northern Spy tree was considerably heavier on the portion of the tree with the light crop in 1937 (portion thinned early in 1935).

loss the year of thinning depends upon the price received per unit that year for the reduced yield. The gain the subsequent year depends in part upon the price of fruit that year. The total gain resulting from the early thinning must be calculated over the 2- or 3-year period.

It seems hardly necessary to point out in passing that the practicability of early thinning depends in part upon the variety thinned. With a variety which normally sells for a higher price per bushel, as McIntosh or Delicious, returns from early thinning will be greater than from a variety whose price per unit is usually much smaller.

The writers have not given the actual time involved in the early thinning, since it would hardly be indicative of that required by growers in an early thinning practice. In the work reported herein special attention was given to leaving a definite fruit cluster to flower cluster ratio, namely, 1 to 4; whereas a grower in following out this practice need not be so arbitrary in the proportion of fruit clusters to flower clusters that would be left on a tree.

### DIRECTIONS FOR GROWERS DESIROUS OF THINNING EARLY

Thin early only on trees of those varieties which usually sell for higher prices per unit.

Early thinning on a tree bearing crops alternately should be completed within 1 month of petal fall if sufficient flowers are to be produced for a full commercial crop the succeeding year.

On the basis of present evidence, only one fruit cluster (containing only one fruit) should be left to four vigorous original flower clusters. (Remove all fruits on weak spurs.) There may be some difference between varieties in this respect. No data are available for the variety Baldwin. The results presented herein were concerned with the trees of the varieties Delicious, Northern Spy, Oldenburg, and Stayman Winesap which were bearing alternately. In other states results indicate that alternate bearing trees of the varieties Jonathan, McIntosh, Yellow Transparent, Yellow Newtown, and York Imperial might be expected to produce similar favorable effects from early thinning.

It does not appear necessary that the fruit clusters be so uniformly spaced as they were in the experiments reported herein. However, on the basis of present fragmentary evidence it would seem unwise to leave more than 30 per cent of the flower clusters with one fruit each. Possibly as more data become available, it may be found that in certain varieties one fruit cluster to three flower clusters will be sufficiently heavy thinning.

In view of the fact that the June drop has not usually been completed at the time of this early thinning, some care must be used in the choice of fruits left. In general, the largest fruit of a cluster should be left unless one is certain that one of the others is not likely to fall in the June drop. Experiments have shown that early thinning reduced to a negligible quantity the drop of the fruits remaining on the tree, provided the thinning had left fruits which were still competing successfully with those adjacent in the same cluster. In case the grower is undecided about certain fruits, a few additional fruits should be left. However, care must be taken that no more than a third of the flower clusters have been left with a single fruit each.

## SUPPLEMENTARY MEASURES

*APPLICATIONS OF NITROGEN-CARRYING FERTILIZERS*

The grower should bear in mind that insofar as the application of nitrogen-carrying fertilizers increases the set of fruit on alternate bearing trees already very vigorous, the alternate bearing condition is accentuated. The desirable condition is no greater set the *heavy* bearing year than is necessary for a satisfactory crop, but this cannot be brought about in view of the nature of fruit setting and the usual vicissitudes of a blooming season. Insofar as nitrogen applications on alternate bearing trees can be omitted or possibly delayed the heavy bearing year, the grower is working in the direction of alleviating the alternate bearing condition. On the other hand, it is desirable that as many fruits as possible (up to a satisfactory commercial crop) should develop the *light* bearing year. Insofar as nitrogen applications increase the set the light flowering year, the nitrogen application that year tends in the direction of alleviating the alternate bearing condition. Furthermore, some of the nitrogen applied the light bearing year will be carried over in storage form until the following year.

## OVERPOLLINATION

Insofar as excessive cross-pollination on alternate bearing trees results in excessive fruit setting, it is undesirable. However, at present there seems no practicable way to insure that only sufficient flowers for a full crop be adequately cross-pollinated. Possibly in alternate bearing blocks of the variety Jonathan (or Rome if the trees are alternating) bees may be reduced to a minimum. However, it should be kept in mind that pollinizing insects are desirable even with varieties such as these, which may set one-half a commercial crop of fruit with their own pollen.

## COST OF GROWING AND HARVESTING APPLES

F. H. BALLOU

This project of keeping an accurate account of all cash expenditures for labor, materials, and more or less closely related incidentals in apple production was begun in the spring of 1924. It has now continued during a period of 14 consecutive years.

The location of this long-term experiment is in a very hilly section of southeastern Licking County, Ohio, on steep slopes and hilltops. The ground on which the 20-acre test block of trees is situated was purchased by the present owner but little less than 40 years ago at the price of \$30 per acre. For many years this land had been subjected to generally prevailing unprofitable and ruinous practices of grain and forage farming.

The age of the greater part of the orchard at the beginning of this experiment in 1924 was 12 years. The varieties of apples predominating were Ensee, Grimes, Jonathan, Stayman, and Rome. A small block of trees, principally of Jonathan, Rome, and Stayman was in its twenty-fifth year. A still smaller section of the ground, about  $2\frac{1}{2}$  acres, was but newly set when this project was started and contained about 100 trees of Red Delicious which had been planted as stocks upon which to top-graft other varieties as such were desired for trial. This report covers expenditures on and yields of fruit from the entire block of 20 acres, regardless of age and bearing capacities of the trees.

The orchard has been fertilized annually with promptly available commercial nitrogenous fertilizers, first with sodium nitrate, next with ammonium sulfate, and in more recent years with Cyanamid. The rate of application has been approximately  $\frac{1}{4}$  pound of fertilizer for each year of age of the trees composing the different plantings included in the orchard as a whole. The fertilizing materials have been applied very early in spring or late in autumn in broad circles or belts beneath and a little beyond the outer extremities of the branches of the trees during the earlier years of their development. As the spread of branches has gradually become greater and the feeding root systems have extended outward into the centers of the spaces between the trees, the fertilizers have been spread more and more nearly over the entire surface of the ground. The small, circular areas immediately around the bases of the trees have been the only part left unfertilized.

The plan of culture of this orchard has been to encourage dense coverage of the soil by heavy, annual growths of vegetation, principally bluegrass. No mulch from outside sources ever has been used, because the orchard is located in a region where little straw or other surplus vegetation is procurable. The cultural plan, therefore, has been to build up an effective grass mulch by mowing the grass in June and again in September. Production of apples in the orchard under discussion has been unfailing and sufficiently heavy to render advisable much more thinning of fruit than it has been possible to do with the limited help available. Size and color of the apples likewise have been all that reasonably could be expected. Obviously, under such cultural treatment, erosion has been avoided during the 14-year term covered by this report. Nor will there be any loss of soil in the future, so long as the present cultural plan is followed.

Spraying for prevention of injury to fruit and foliage by fungous diseases and insects has been done with strict regard to both timeliness and thoroughness of application. In only two instances during the past 14 years did exceptions occur, and these in only small parts of the orchard.

Portable power spraying outfits of different types were used exclusively previous to and during the first two seasons of the orchard project now under discussion. For a 5-year period following, dusting was given exacting trials in comparison with spraying. New equipment for both methods of treatment was purchased. During the more recent period of 8 years, heavy-duty stationary spraying machinery has been used exclusively and with much satisfaction.

Annual or biennial pruning, as seasonal conditions and different varieties have rendered advisable, has been practiced during the 14 years this experiment has progressed. Rather light pruning has been favored, just sufficient to remove dead, dying, broken, crowding, and no longer useful branches; to prevent the trees from attaining inconvenient heights; and to admit sunshine to all parts of the trees. Such pruning makes efficient spraying much easier.

**TABLE 1.—Record of Growing and Handling Apples in a Very Hilly Section of Central Ohio During a Period of 14 Consecutive Years**

Year	Cost of growing*	Cost of harvesting and packing†	Cost of packages, trucking, storage, etc.	Overhead expenses‡	Yields	Total cost of crops
	<i>Dol.</i>	<i>Dol.</i>	<i>Dol.</i>	<i>Dol.</i>	<i>Bu.</i>	<i>Dol.</i>
1924.....	385.53	502.49	1,034.27	162.45	2,166	2,084.74
1925.....	431.80	545.18	877.31	158.88	2,676	2,013.17
1926.....	564.72	661.44	697.48	147.50	3,120	2,071.14
1927.....	475.20	805.10	944.23	297.00	3,300	2,521.53
1928.....	711.05	597.50	861.46	445.62	2,298	2,619.63
1929.....	751.77	529.55	611.14	436.96	1,900	2,323.42
1930.....	696.48	634.87	553.99	618.62	1,700	2,503.96
1931.....	656.75	831.17	1,249.14	626.28	5,000	3,413.34
1932.....	704.88	845.35	1,094.99	469.46	5,400	3,114.68
1933.....	625.32	659.86	668.92	445.99	5,000	2,400.09
1934.....	568.60	401.20	671.02	422.91	2,676	2,063.73
1935.....	726.79	832.25	1,475.61	392.61	6,400	3,427.26
1936.....	676.12	913.25	770.54	354.52	4,600	2,714.43
1937.....	919.35	1,631.10	1,546.34	337.04	6,300	3,833.83
<b>Totals.....</b>	<b>8,894.36</b>	<b>9,840.31</b>	<b>13,056.44</b>	<b>5,313.84</b>	<b>53,536</b>	<b>37,104.95</b>
Average cost per bushel per year, ct.....	17	18	24	10		69

\*The cost of growing includes pruning, fertilizing, spraying, thinning, and all materials entering into production of the fruit in the orchard.

†The cost of harvesting includes picking, hauling the apples from the orchard to the packing house, sizing, sorting, packing, and supervision of packing and salesrooms.

‡Overhead costs include interest on investment in orchard land and equipment, depreciation of value of equipment, repairs, taxes on assessed value of land and equipment, etc.

During a considerable period of years, providing there are no serious crop shortages, the annual orchard costs of growing apples up to the time they are ready to be harvested are more nearly uniform than are any of the other divisions of expenditures. This is true because whether there are moderate or generous yields, the costs of pruning, fertilizing, spraying, and mowing, without much variation, must be borne annually. It is possible, however, that a serious exception may occur occasionally, as in a season of scant production or almost complete failure of the crop.

Next, perhaps, in uniformity of costs are the items of picking the apples, moving them from the orchard to the packing house, sizing, sorting, and packing. Expenditures for these operations depend largely on the cost and quality of labor, and on the proportion of the crop that may be sold locally for immediate use at harvest time. The proportions of the crops that have to be packed carefully for cold storage, as well as sized and graded, add several cents per bushel to the cost of handling.

In no division of expense for apple production and handling are the costs so great or so variable as in that for packages, transportation, cold storage, and the like. Without exception the greater fluctuations of cost in this classification are due to widely ranging expenditures for packages. In seasons of general or even local scarcity of apples, a brisk demand from near-by sections usually results, and the same containers, new at the outset, may be emptied and refilled a number of times during the period of harvesting and grading. In seasons of widespread overproduction, a much greater supply of packages with all the modern accessories must be provided. These all pass on to cold storage and to the ultimate dealers and purchasers. Cold storage, however, is the greatest single item of expense with which the apple grower has to contend.

As may be noted by referring to Table 1, there is wide variation in annual overhead expenses. These variations are due principally to purchase of larger and more expensive orchard equipment, and to charging against the value of such equipment, annually, a constant percentage in allowance for depreciation. A rate of 10 per cent plus repairs and replacement of parts has been charged against mechanical equipment, and 5 per cent plus repairs, on buildings that are necessary in handling crops of fruit and housing orchard equipment.

## SPRAYING AND DUSTING FOR CABBAGE WORM CONTROL

HARRY L. GUI

The leaves of cabbage and related crops grown in Ohio are damaged seriously by three caterpillars. These are the imported cabbage worm, *Ascia rapae* (Linn.); the cabbage looper, *Autographa brassicae* Riley; and the larva of the diamond-back moth, *Plutella maculipennis* Curtis. Other species of insects, such as the corn ear worm and several cutworms, inflict damage to foliage and heads in late summer and autumn. They are seldom sufficiently numerous on cabbage at that time to warrant special attention.

For many years the standard recommendation for the control of cabbage worms has been calcium arsenate applied in the form of dust or in liquid sprays. More recently, however, this treatment has fallen into disrepute because the degree of control was unsatisfactory. Without doubt, if a sufficient amount of calcium arsenate were applied to cabbage foliage to control the worms, the poisonous residue remaining on the edible parts would greatly exceed the tolerances established by Federal regulations.

It became necessary, therefore, to rework the entire problem of cabbage worm control. This work was started in 1934 and although the project is still in progress it is believed that the findings to date are of sufficient importance to warrant their being placed at the disposal of Ohio growers.

A wide variety of insecticides which have included arsenicals, fluorines, pyrethrums, rotenones, and a few other materials have been used in this project. These have been tested at different strengths and in combination with several diluents, spreaders, and stickers. The interval between applications of the insecticides was varied in order to establish the smallest number of treatments that would bring about a commercial control of the pests in question.

In order to make all these tests, a large number of plots was used each year. In 1934, 24 treatments were replicated six times, or a total of 144 plots was used. In 1935, 46 treatments were replicated six times; in 1936, 48 treatments five times; and in 1937, nine treatments eight times. Only a few of the more efficient or formerly recommended materials are mentioned in this publication, and only data which have a bearing on the degree of control as measured at the time of harvest are presented.

Wisconsin Hollander No. 8 cabbage was used in all tests. The plants were set about July 1 and the application of insecticides was begun about August 1 of each year.

## DUSTING AND SPRAYING EXPERIMENTS

1934-1935-1936

The method used for measuring the degree of damage was the same for the first 3 years. It consisted of grouping the heads on the basis of the number of leaves lost in the process of removing all worm damage. The cabbage was cut and trimmed so that four leaves which did not enfold the head tightly more than two-thirds of the distance from the base to the top remained on the head. This way of trimming conforms with the requirements for the U. S. No. 1 grade of cabbage. All heads entirely free from worm damage and those from which the worm damage could be removed by trimming off two layers of leaves were classed as "marketable" for the purpose of this publication.

The percentages of marketable heads (as determined by the foregoing method) which were produced under dusting schedules are given in Table 1.

TABLE 1.—The Percentage of Marketable Heads Produced on Dusted Plots

Poison	Diluent	Marketable heads		
		1934	1935	1936
		<i>Pct.</i>	<i>Pct.</i>	<i>Pct.</i>
Paris green.....	Hydrated lime	100	93	88
Paris green.....	Flour			
Derris powder.....	Diatomaceous clay	75		
Derris powder.....	Flour		91	70
Lead arsenate.....	Hydrated lime and diatomaceous clay		90	
Calcium arsenate.....	Hydrated lime	24		
Calcium arsenate.....	Diatomaceous clay			50
Check (no treatment).....		19	36	30

In each of the 3 years, Paris green was more effective in control than any other material. However, such small differences occurred between the three better materials in 1935 that they must be considered equal in efficiency for that year. The use of calcium arsenate resulted in the production of a low percentage of marketable heads; in fact, during the 2 years it was used the plots so treated were but slightly better than the checks.

The results from the sprayed plots are given in Table 2.

TABLE 2.—The Percentage of Marketable Heads Produced on Sprayed Plots

Poison	Spreader and sticker	Marketable heads		
		1934	1935	1936
		<i>Pct.</i>	<i>Pct.</i>	<i>Pct.</i>
Paris green.....	None	22		
Paris green.....	Grasselli Spreader		97	
Paris green.....	Fish oil			93
Derris powder.....	Goulac	33		
Derris powder.....	Grasselli Spreader		97	70
Lead arsenate.....	Grasselli Spreader		91	59
Calcium arsenate.....	Goulac	8		
Calcium arsenate.....	Grasselli Spreader			52
Check (no treatment).....		19	36	30

It is believed that the inferior control from all sprays in 1934 was due to the use of a knapsack sprayer, the only machine available at that time. Evidently, the pressure was inadequate to break the spray into fine particles and to force it among the leaves of the cabbage plants. As a result, complete wetting could not be obtained. During 1935 and 1936 a power sprayer which developed a pressure of 200 pounds or more per square inch was used. The control obtained at the higher pressure was more satisfactory. This stresses the importance of proper and thorough application of materials.

Paris green and derris powder were identical in degree of control in 1935 and each was but slightly better than lead arsenate. In 1936, Paris green was better than derris powder spray and both excelled lead arsenate to a significant degree. Calcium arsenate used in spray form in 1936 was almost as effective as lead arsenate.

### DUSTING AND SPRAYING EXPERIMENTS, 1937

The type of data collected in 1937 was such that a direct comparison with the work of the 3 preceding years could not be made, but it enabled us to obtain a better measurement of the effect of the treatments. The cabbage from each plot was cut and trimmed to conform with U. S. No. 1 grade and weighed. Then we determined the percentage of heads entirely free from worm damage. These records are shown in Table 3. Data on yield and loss by further trimming to remove leaves damaged by worms will be shown in Table 6.

**TABLE 3.—Cabbage Heads Trimmed to U. S. No. 1 Specifications  
Free from Worm Injury, 1937 Tests**

Formula	Heads free from visible injury	
	<i>Pct.</i>	
Paris green ..... 2 lb.	{	34
Grasselli Spreader ..... 4 oz.		
Water ..... 50 gal.		
Derris powder (4 per cent rotenone) ..... 1 lb.	{	34
Talc ..... 7 lb.		
Paris green ..... 1 lb.	{	30
Talc ..... 10 lb.		
Zinc arsenite ..... 2 lb.	)	29
Hydrated lime ..... 2 lb.		
Grasselli Spreader ..... 4 oz.		
Water ..... 50 gal.		
Derris powder (4 per cent rotenone) ..... 1½ lb.	{	27
Grasselli Spreader ..... 4 oz.		
Water ..... 50 gal.		
Check (no treatment).....		14

In this test the highest percentage of cabbage heads with no insect damage was produced by the plots sprayed with Paris green and those dusted with derris powder. The derris powder spray did not control as well as the other treatments, but the percentage of injury-free heads produced was more than twice that of the check plots. Zinc arsenite was tried for the first time. The results were promising.

### THE EFFECT OF DUSTING AND SPRAYING UPON YIELD OF CABBAGE

Yield records are available for 3 years. In 1934, a lack of uniformity in the soil upon which the plots were located made it impossible to obtain dependable yield data. The yields produced by the dusted plot in 1935 and 1936 are given in Table 4. The yield data represent the net weight of the cabbage after all damaged leaves had been removed from the heads.

TABLE 4.—Yield of Cabbage Produced on Dusted Plots, 1935 and 1936

Poison	Diluent	Yield per acre	
		1935	1936
Paris green.....	Hydrated lime	<i>Lb.</i> 14,817	<i>Lb.</i> .....
Paris green.....	Flour	.....	18,427
Derris powder.....	Flour	12,635	14,310
Lead arsenate.....	Hydrated lime and diatomaceous clay	12,332	.....
Calcium arsenate.....	Diatomaceous clay	.....	9,550
Check (no treatment).....	.....	10,181	11,675

The largest yield in the dusted series was produced on plots upon which Paris green had been used. The yield from the plots treated with lead arsenate was approximately equal to that from plots dusted with derris powder. The smallest yield came from plots dusted with calcium arsenate in 1936. Why this yield was less than that of the check was not determined.

The effect of sprays on yield is presented in Table 5. In this table the column "yield per acre" represents the weight of the cabbage remaining after all leaves damaged by worms had been removed from the heads.

TABLE 5.—Yield of Cabbage Produced on Sprayed Plots

Poison	Spreader and sticker	Yield per acre	
		1935	1936
Paris green.....	Grasselli Spreader	<i>Lb.</i> 15,241	<i>Lb.</i> .....
Paris green.....	Fish oil	.....	13,611
Derris powder.....	Grasselli Spreader	12,241	15,252
Lead arsenate.....	Grasselli Spreader	16,120	16,140
Calcium arsenate.....	Grasselli Spreader	.....	12,482
Check (no treatment).....	.....	10,181	11,675

The largest yields came from plots sprayed with lead arsenate, although the percentage of worm control, as has been shown previously, was not as pronounced as it was where other materials were used. The yield data from plots sprayed with Paris green and derris are not consistent, in that the standing of the two materials was reversed in 1935 and 1936.

The yield data taken in 1937 differ from those of 1935 and 1936, in that they give the gross weight of the crop trimmed to U. S. No. 1 grade; the weight after the heads had been trimmed to remove all leaves injured by worms; and the weight of the leaves removed. From these figures it is possible to determine the actual loss of cabbage caused by the insects, which is given in the column headed "tare". All these data are shown in Table 6.

TABLE 6.—The Yield of Cabbage and Losses Due to Worm Damage in the 1937 Tests

Formula		Yield per acre			
		Gross	Trimmed to remove worm damage		
			Net	Tare	Gain over check
Derris powder (4 per cent rotenone).....	1 lb.	31,698	29,857	1,841	6,135
Talc.....	7 lb.				
Zinc arsenite.....	2 lb.	31,298	28,221	3,077	4,499
Hydrated lime.....	2 lb.				
Grasselli Spreader.....	4 oz.				
Water.....	50 gal.				
Derris powder (4 per cent rotenone).....	1½ lb.	29,448	26,994	2,454	3,272
Grasselli Spreader.....	4 oz.				
Water.....	50 gal.				
Paris green.....	2 lb.	28,835	26,790	2,045	3,068
Grasselli Spreader.....	4 oz.				
Water.....	50 gal.				
Paris green.....	1 lb.	28,017	26,585	1,432	2,863
Talc.....	10 lb.				
Check (no treatment).....		26,994	25,722		

All the materials named in Table 6 increased the yield considerably over the yield of the untreated check. The Paris green treatments did not yield as well by comparison with derris powder as in other years. This was due at least in part to plant injury by the insecticide. There was a very slight amount of visible injury to the leaves in 1937; whereas in previous years none was observed.

### RECOMMENDATIONS

The cabbage worm control project has yielded data which permit the following recommendations to be made:

The crop should be dusted or sprayed at 10-day intervals with Paris green or derris powder.

Paris green dust should be prepared by mixing 1 pound of Paris green with 10 of a diluent.

Any of the common diluents, such as talc, diatomaceous clay, or lime, may be used. Flour is an excellent diluent, and when it is mixed half-and-half with other diluents, the adhesive qualities of the dust are greatly increased.

Paris green sprays should consist of 2 pounds of Paris green to 50 gallons of water. A spreader and sticker is necessary.

Fish oil is a desirable spreader and sticker when used at the rate of 2 ounces to 50 gallons of spray material. Several proprietary spreaders and stickers are available. These should be used according to the manufacturer's directions.

Derris powder dusts should contain not less than 0.5 per cent of rotenone. One pound of derris powder of 4 per cent rotenone content should be used to 7 pounds of the diluent.

Desirable diluents for derris powder are flour, talc, diatomaceous clay, dusting gypsum, and finely ground tobacco stems.

Derris powder sprays should consist of 1½ pounds of derris powder containing 4 per cent rotenone in 50 gallons of water. When other grades of derris powder are used, dosage should be so calculated that the spray contains 0.015 per cent of rotenone. A spreader and sticker should be used.

Federal regulations prohibit excessive residues of poison on marketed cabbage; therefore Paris green should not be applied after the heads begin to form. Derris powder may be used after that date or throughout the season if desired. There are no regulations at the present time concerning residues of rotenone on fruits and vegetables.

## EVAPORATION STUDIES. II. THE INFLUENCE OF PAN COLOR ON EVAPORATION

J. D. WILSON AND C. A. PATTON

The use of black and white atmometers to measure the effect of solar radiation on evaporation, as distinguished or separate from the influence of other factors, has been a common practice for several years (1, 2). During the early progress of an evaporation study carried on at Wooster during the past 10 years (3), it was noticed that variations in water loss from a standard Weather Bureau evaporation pan seemed to correspond more closely, day by day, to the losses from the black than from the white atmometer. This indicated that the galvanized material of which the pan was made must be absorbing a very considerable portion of the radiant energy striking it. To determine if this was true an experiment was designed to test the influence of pan color on the rate of evaporation from the surface of water contained in the pan.

Briggs and Shantz (4) made use of a pan blackened on the inside in comparing hourly losses by evaporation from various types of evaporimeters with corresponding transpirational losses of alfalfa. They found the losses from the shallow, blackened pan to correspond most closely, hour by hour, with those from the alfalfa plants.

In consideration of the findings of Briggs and Shantz (4) and the fact that black and white atmometers were already being used to measure the influence of the sunlight factor in evaporation (3), it was decided to use three pans and

1. Livingston, B. E. 1935. Atmometers of porous porcelain and paper, and their use in physiological ecology. *Ecology* 16: 438-472.

2. Wilson, J. D. 1937. Evaporation studies. I. A survey of evaporation and light values in greenhouses. *Ohio Agr. Exp. Sta. Bimo. Bull.* 22: 87-97.

3. Wilson, J. D. 1935. Studies in evaporation. *Ohio Agr. Exp. Sta. Bull.* 548, Fifty-third Ann. Rep., p. 35.

4. Briggs, L. J. and H. L. Shantz. 1917. Comparison of the hourly evaporation rate of atmometers and free water surfaces with the transpiration of *Medicago sativa*. *Jour. Agr. Res.* 9: 277-292.

make a comparison of the rates of water loss from a black, a white, and an untreated galvanized one. These pans were 10 inches deep and 2 feet in diameter (unlike the standard 4-foot pan in diameter) and the painted ones were treated both inside and out. They were then placed near a standard Weather Bureau pan and a battery of black and white atmometers. The loss of water by evaporation from these small pans was measured in the same manner and at the same time each day as was that from the standard pan. The average monthly water losses from May to September, inclusive, over a 3-year period, from the four pans and the black and white atmometers are shown in Table 1.

TABLE 1.—Average Evaporation Losses at Wooster for the Summer Months from Differently Colored Pans and Black and White Atmometers (3-year Average)

	Pans						Atmometers				
	Black	White	Galvanized	Weather Bureau	Black minus white	White Black	Black	White	Black minus white	Black minus white	White Black
	<i>In.</i>	<i>In.</i>	<i>In.</i>	<i>In.</i>	<i>In.</i>	<i>Pct.</i>	<i>C. c.</i>	<i>C. c.</i>	<i>C. c.</i>	<i>In.</i>	<i>Pct.</i>
May...	5.46	4.50	5.39	4.58	0.96	82.4	1188	850	338	1.32	71.4
June...	6.21	5.23	6.09	5.08	0.98	84.2	1272	900	372	1.43	70.8
July...	7.37	6.37	7.32	5.76	1.00	86.3	1396	976	420	1.64	70.0
Aug...	6.06	5.08	5.82	4.36	0.98	82.2	1115	767	348	1.36	68.8
Sept...	4.65	3.68	4.42	3.85	0.97	79.6	1082	757	325	1.27	70.0
Total..	29.75	24.86	29.04	23.63	4.89	83.6	6053	4250	1803	7.02	70.2

First, it will be noticed that the small pans (2 feet in diameter) lost a considerably greater depth of water than did the standard pan (4 feet in diameter). The small galvanized pan lost 22.9 per cent more than the large one. This was to be expected, since evaporation from circular areas is not proportional to the areas involved but to the first power of the surface; therefore, a small area, such as that represented by one of these pans, should lose a greater depth of water in a given time and under the same conditions than a larger one. A comparison of the losses from the three small pans shows that the untreated pan (galvanized) lost only 2.4 per cent less water than the blackened one and approximately 17 per cent more than the white one. In other words, the untreated pan was nearly as efficient in absorbing radiant energy as was the blackened one. The difference between the losses from the black and white pans is not as great as that between the black and white atmometers.

When the relative losses from the atmometers are translated into inches by means of a conversion factor (3), the black minus white (B—W) value is nearly 44 per cent greater than the B—W value for the black and white pans. The B—W value for pans is 16.4 per cent of the loss from the black one; whereas the atmometer value of B—W (radiation effect) accounts for 30 per cent of the loss from the black atmometer.

A further analysis of the data in Table 1 indicates that although the B—W value for the pans is greatest in July, the difference between the value for this month and that of any other of the 4 months included in the tests is not nearly as great proportionately as it is for the atmometer values of B—W. Thus, when July is taken as unity (100), May, June, August, and September values are 96, 98, 98, and 97 and 81, 89, 83, and 77 for the pans and the atmometers, respectively. The corresponding values for hours of sunshine duration as

measured by the Marvin recorder are 83, 83, 78, and 76, respectively. When data on sunlight intensities at Madison, Wisconsin (5), for the same period are considered, the relative values for May, June, July, August, and September are 82, 90, 100, 79, and 63. It will be noted that these intensity data correspond much more closely to those for the atmometers than those for the pans. The relative monthly values for B—W of the atmometers and the solar radiation values from the pyrliometer of the Weather Bureau check very closely for all months but September. It is possible that the smaller relative values of the latter for May, August, and September are partly accounted for by the difference in latitude between Wooster and Madison. In any event, these various data indicate that, although a black pan absorbs considerably more radiation than a white one, it still is not nearly as efficient an instrument for evaluating the influence of the radiation factor on evaporation as is the black atmometer, and this is probably equally true regarding the reflection coefficients of the white pan and white atmometer.

The pans showed a greater spread between the maximum July values and the minimum May and September values of evaporation than did the atmometers. This is particularly noticeable when the white pan and white atmometer are compared. This would indicate that the pan is probably more affected by the seasonal variations in temperature and is less responsive to the influence of such factors as wind, vapor pressure deficit, barometric pressure, etc., than is the atmometer. The standard pan, strangely enough, behaved more like the atmometers in this respect than did the smaller pans.

In summary, the most important observations relative to this study are: The black pan lost considerably more water than the white one. The differences were in the same order as those in the radiant energy factor; they were less marked than those existing between the black and white atmometer and made up a smaller percentage of the total loss due to all factors. Finally, the water losses from the galvanized pan correspond more closely to those from the black than from the white pan; this indicates the untreated material (galvanized iron) to be very efficient in absorbing radiant energy.

5. Kimball, H. H. 1927. Measurements of solar radiation intensity and determinations of its depletion by the atmosphere with bibliography of pyrliometer measurements. *Mon. Weather Rev.* 55: 155-169.

## ANNOUNCEMENT OF SPECIAL DAYS FOR 1938

### AT WOOSTER

Greenhouse Vegetable Day .....May 5

American Dairy Science Association .....June 17

The American Dairy Science Association consists of college and experiment station men from the United States and Canada who are interested in dairy science. The Association meets at the Ohio State University June 14, 15, and 16, and at the Station June 17. There will be three addresses at the Station on the effects of dairy research on the dairy industry.

Wheat and Clover Day .....June 30

Poultry Day .....July 28

The Twenty-second Annual Ohio Poultry Day at Wooster is to be a combined Ohio Poultry Day and pre-anniversary celebration of the Seventh World's Poultry Congress and Exposition to be held at Cleveland, Ohio, July 28 to September 7, 1939.

Professor James E. Rice, General Chairman of the World's Poultry Congress, will be one of the prominent guest speakers.

Dairy Day .....August 12

Orchard Day .....August 19

Feed Merchants' Day	}	Date to be announced
Livestock Day		

### AT THE DISTRICT AND COUNTY FARMS

Field Day, Washington County Truck Farm .....July 9

# THE ULTRAVIOLET ABSORPTION SPECTRA OF SOME MONOAZO DYES

MARION E. GRIFFITH<sup>1</sup> AND WALLACE R. BRODE<sup>2</sup>

## INTRODUCTION

The problem reported here involves a study of the relationship between the position of sulfonic acid group substitution in a series of phenyl azo-sulfonic acid dyes and their absorption spectra in the visible and ultraviolet regions of the spectrum. The dyes used, their method of preparation, purification, and analysis have been described previously (1).

A similar study of phenyl azo naphthylamine sulfonic acid dyes has been reported by Eberhart (2) and reference will be made here to his study.

## DETERMINATION OF ABSORPTION SPECTRA

The absorption spectra in the visible region of the spectrum were determined by means of a Bausch and Lomb spectrophotometer.<sup>3</sup>

The ultraviolet absorption spectra were determined by the Hilger sector photometer method with a Bausch and Lomb spectrograph. This method has been described by Brode (3). The absorption spectrum of each of the 37 dyes was determined in neutral aqueous solution. The concentration of dye used for the solutions was  $2.10^{-4}$  gram mol per liter, with the exception of those dyes listed in Table 1. All dye solutions were stored in the dark and did not show any fading.

TABLE 1.—Concentration of Dye Solutions

Gram mol per liter		
$2.10^{-5}$	$1.05^{-4}$	$0.52^{-4}$
M-2:6 O-2:7 M-2:7 S-2:7 A-2:3, 6 M-2:3, 6 S-2:3, 6 O-2:6, 8 M-2:6, 8 O-1:3, 8 M-1:3, 8	A-2:7	A-1:3 O-1:3 M-1:3 S-1:4 A-2:6 O-2:3, 6

<sup>1</sup>Formerly Associate, Department of Home Economics, Ohio Agricultural Experiment Station. Now Assistant Professor, Department of Clothing and Textiles, School of Home Economics, Purdue University, Lafayette, Indiana.

<sup>2</sup>Associate Professor, Department of Chemistry, Ohio State University.

1. Griffith, M. E. and W. R. Brode. April, 1936. Ohio Agr. Exp. Sta. Bull. 565.

2. Eberhart, D. R. and W. R. Brode. 1936. Doctors Dissertations 18: 123. The Ohio State University Press.

<sup>3</sup>See bulletin entitled "The Universal Spectrophotometer" issued by the Bausch and Lomb Company.

3. Brode, W. R. 1929. Bureau of Standards, Jour. of Research 2: 501. 1934. Jour. Am. Chem. Soc. 56: 2172.

## RESULTS

The position of the sulfonic acid group in the benzene nucleus appears to have only a slight effect on the position of the absorption band in the visible region of the spectrum. The ortho- and meta-sulfonated compounds have bands which fall between 470 and 500  $m\mu$ ; those of the para-sulfonated compounds fall between 480 and 500  $m\mu$ . The unsulfonated aniline produces a slight hypsochromic effect; whereas the para-sulfonated dyes show a stronger hypsochromic effect as well as an increase in intensity.

Where substitutions occur in the second component, the hypsochromic effect increases as the sulfonic acid group moves from the 3, to the 4, to the 5 position. The hypsochromic effect is greater with the beta-naphthol dyes than with the alpha-naphthol dyes, and here again the hypsochromic effect increases as the sulfonic acid group goes from the 6 to the 7 position.

The 37 dyes studied can be divided into two structural types on the basis of the parent non-sulfonated hydroxyazo dyes. In an earlier discussion (2) on the aminoazo dyes a similar classification was used in which three types were indicated (Fig. 1).

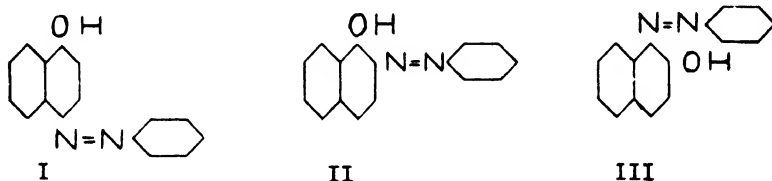


Fig. 1.—Three dye types

In order to be consistent with these data, the two types described in this paper will be referred to as Types II and III. Type II is formed whenever the sulfonic acid group occurs in the 3, 4, or 5 position. As one might expect, the absorption curves are quite different in the various dye types, although the difference between Types II and III is not as great as between either of these types and Type I, since Types II and III are both ortho coupled; whereas Type I is a para coupled dye. Since there were no Type I dyes in the series which is being reported, it is not possible to show the marked differences that were apparent in the study of the amino series.

The Type II dyes in neutral solution are characterized by three strong bands which are well separated and of nearly the same intensities. In general there is a bathochromic effect as one goes from the 1:3 to the 1:4 to the 1:5 dyes, in the low- and high-frequency absorption bands. (Fig. 2).

The Type III dyes in the hydroxyazo dyes do not differ as markedly from the Type II dyes as in the corresponding aminoazo series. There are, however, only two distinct maxima which appear, and there is little evidence for a distinct shift of the maxima with a change in the position of substitution in either the benzene or naphthalene ring. (See Figure 3 for a typical curve of a Type III dye.) Table 2 gives the data on the position of the absorption maxima of all of the Type II and Type III dyes that were studied in this series.

A-1:4  
A-1:3  
S-1:5  
S-1:4  
S-1:3  
M-1:5  
M-1:4  
M-1:3  
O-1:5  
O-1:4  
O-1:3

Fig. 2.—Frequencies of the principal maxima of Type II dyes showing the effect of varying the position of sulfonic acid group substitution in the benzene nucleus

TABLE 2.—Absorption Spectra Data

Dye	Frequencies of principal maxima		
A-1:3	615	825	1040
A-1:4	605	870	1010
A-1:5	590	885	975
O-1:3	625	850	1070
O-1:4	615	835	1015
O-1:5	600	870	980
M-1:3	625	810	
M-1:4	615	840	1020
M-1:5	600	880	980
S-1:3	600	875	1025
S-1:4	610	825	1035
S-1:5	600	875	1005
A-2:6	615	925	1150
A-2:7	615	935	1140
O-2:6	625	975	1150
O-2:7	625	960	
M-2:6	630	950	1140
M-2:7	625	960	
S-2:6	625	960	1140
S-2:7	615	935	
A-2:3, 6	600	940	
A-2:6, 8	610	920	
A-1:3, 8	600	1030	
O-2:3, 6	605	950	
O-2:6, 8	625	930	1140
O-1:3, 8	620	1060	
M-2:3, 6	610	940	
M-2:6, 8	610	920	
M-1:3, 8	600	1030	
S-2:3, 6	600	940	
S-1:3, 8	605	1025	

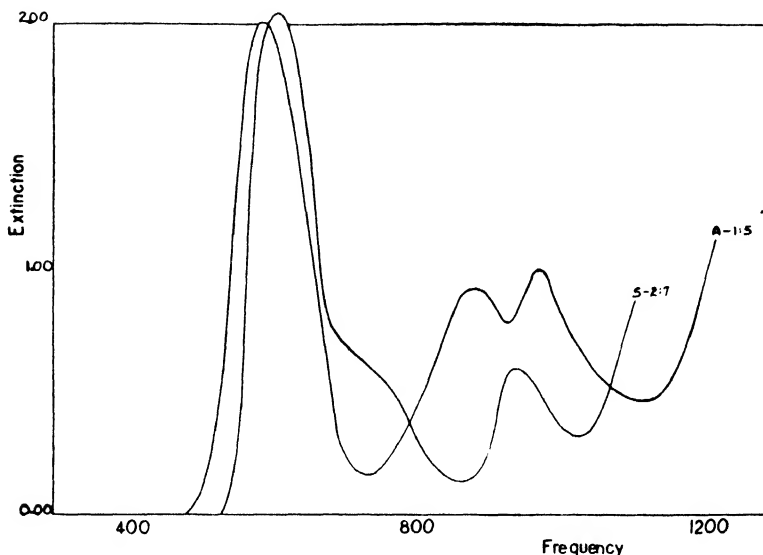


Fig. 3.—Typical curves for Type II (A-1:5) and Type III (S 2:7) dyes

### CONCLUSIONS

1. The position of substitution of a sulfonic acid group in either the diazo or the coupling component of these azo dyes determines the effect produced by the sulfonic acid group.
2. Sulfonic acid groups introduced into the naphthalene nucleus usually produce a bathochromic effect which is greatest for dyes from 1-naphthol-5-sulfonic acid. The bathochromic effect is very similar with the ortho-, meta-, and para-sulfonated diazo components.
3. The intensity of absorption produced was greatest where substitution occurred in the para position of the diazo component. The intensity of absorption appears to be a function of the portion of the sulfonic acid groups, and in many cases there is a similarity between the intensity of absorption and the positions of the bands.
4. The existence of similar harmonic frequency multiplets in this series where the bands have a simple relation of 3, 4, and 5 times the multiple frequency is not as clearly demonstrated here as in the aminoazo series which has been described previously.

# INDEX NUMBERS OF PRODUCTION, PRICES, AND INCOME

J. I. FALCONER

From July, 1937, to February, 1938, the prices received for Ohio farm products declined 24 per cent. During the same period the prices paid by farmers for commodities purchased declined 5 per cent.

The selling price of farm land in the spring of 1938 showed little change from one year ago. Evidently the rise in farm land values which began in the spring of 1933 has been at least temporarily halted.

## Trend of Ohio Prices and Wages, 1910-1914=100

	Wholesale prices, all commodities U. S.	Weekly earnings N. Y. State factory workers	Prices paid by farmers	Farm products prices U. S.	Ohio farm wages	Ohio farm real estate	Ohio farm products prices	Ohio cash income from sales
1913.....	102	.....	101	101	104	100	105	101
1914.....	99	100	100	101	102	102	105	108
1915.....	102	101	105	98	103	107	106	111
1916.....	125	114	124	118	113	113	121	121
1917.....	172	129	149	175	140	119	182	199
1918.....	192	160	176	202	175	131	203	240
1919.....	202	185	202	213	204	135	218	266
1920.....	225	222	201	211	236	159	212	226
1921.....	142	203	152	125	164	134	132	130
1922.....	141	197	149	132	145	124	127	130
1923.....	147	214	152	142	166	122	134	144
1924.....	143	218	152	143	165	118	133	146
1925.....	151	223	157	156	165	110	159	174
1926.....	146	229	155	145	170	105	155	177
1927.....	139	231	153	139	173	99	147	165
1928.....	141	232	155	149	169	96	154	156
1929.....	139	236	153	146	169	94	151	165
1930.....	126	226	145	126	154	90	128	137
1931.....	107	207	124	87	120	82	89	100
1932.....	95	178	107	65	92	70	63	73
1933.....	96	171	109	70	74	59	69	85
1934.....	110	182	123	90	77	63	85	98
1935.....	117	191	125	108	87	68	110	127
1936.....	118	199	124	114	100	74	118	147
1937.....	126	.....	131	121	118	77	128	161
1936								
July.....	118	198	123	115	105	.....	121	189
August.....	119	202	126	124	.....	.....	131	183
September.....	119	198	127	124	.....	.....	127	169
October.....	119	202	127	121	108	.....	124	164
November.....	120	201	127	120	.....	.....	123	158
December.....	123	211	128	126	.....	.....	127	160
1937								
January.....	125	209	130	131	104	.....	128	151
February.....	126	211	132	127	.....	.....	127	141
March.....	128	218	132	128	.....	77	129	157
April.....	128	219	134	130	118	.....	134	170
May.....	127	219	134	128	.....	.....	135	164
June.....	127	220	134	124	.....	.....	134	162
July.....	128	218	133	125	123	.....	138	191
August.....	128	220	132	123	.....	.....	135	171
September.....	128	215	130	118	.....	.....	129	164
October.....	125	214	128	112	127	.....	123	156
November.....	122	205	127	107	.....	.....	116	156
December.....	119	207	126	104	.....	.....	114	142
1938								
January.....	118	201	126	102	115	.....	109	135
February.....	116	.....	126	97	.....	.....	105	121
March.....	.....	.....	.....	.....	.....	75	.....	.....





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## Ohio Agricultural Experiment Station

WOOSTER, OHIO, U. S. A.



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# INFLUENCE OF RESIDUE COLOR OF BORDEAUX MIXTURE ON TRANSPIRATION IN SUN AND SHADE

J. D. WILSON AND H. A. RUNNELS

## INTRODUCTION

Bordeaux mixture is capable of modifying certain of the physiological functions and in some instances even the anatomy of plants to which it is commonly applied (1, 2). This is especially true of the leaves which bear the spray residue. If this residue has a high reflective capacity for heat and light (white, or a light shade of color, such as a high-lime Bordeaux mixture), the internal temperature of the leaf beneath will be lower than that of similar but untreated leaves during periods of sunshine. Leaves bearing a dark residue (such as Bordeaux mixture plus lampblack), with a heat absorptive capacity greater than that of an unsprayed leaf, will be warmer than untreated leaves in sunlight (3).

By affecting the daytime temperature of leaves to which it is applied, Bordeaux mixture alters the transpiration rate. The magnitude of any decrease or increase in the rate of water loss is determined finally, however, by the balance attained between the warming or cooling effect of the spray residue and the cooling effect of transpiration itself. The effect of any other properties inherent in Bordeaux mixture which are also capable of altering the rate of water loss under various conditions must also be considered. A lowering of the leaf temperature in relation to that of the surrounding air acts to decrease the vapor pressure gradient existing between the two, and water vapor from the leaf then escapes more slowly to the air. The opposite effect prevails when the leaf temperature is increased by the application of a dark residue, and the corresponding increase in vapor pressure gradient is equivalent to a decrease in the relative humidity of the air surrounding the leaf, with the result that the transpiration rate is increased (4). Thus, during the day, and without regard for other regulatory factors, light-colored (cooling) spray residues may be expected to cause a reduction in the normal rate of water loss, as represented by untreated leaves; whereas dark-colored (warming) residues usually increase the transpiration rate.

The ultimate action of Bordeaux mixture is to increase the transpiration rate of most plants to which it is applied. It is particularly effective in this respect during dry nights, on dull days, and even during cloudy periods of partially sunny days (5, 6, 7). Under these conditions the influence of residue

1. Wilson, J. D. and H. A. Runnels. 1931. Bordeaux mixture as a factor increasing drouth injury. *Phytopath.* 21: 729-738.
2. Wilson, J. D. and H. A. Runnels. 1933. Some detrimental effects of spraying tomatoes with Bordeaux mixture. *Ohio Agr. Exp. Sta. Bimo. Bull.* 18: 4-15.
3. Tilford, P. E. and C. May. 1929. The effect of Bordeaux mixture on the internal temperature of potato leaflets. *Phytopath.* 19: 943-949.
4. Curtis, O. F. 1936. Comparative effects of altering leaf temperatures and air humidities on vapor pressure gradients. *Plant Physiol.* 11: 595-603.
5. Duggar, B. M. and J. S. Cooley. 1914. The effect of surface films and dusts on the rate of transpiration. *Ann. Mo. Bot. Gard.* 1: 1-22.
6. Wilson, J. D. and H. A. Runnels. 1933. Some effects of Bordeaux mixture on transpiration. *Ohio Agr. Exp. Sta. Bimo. Bull.* 18: 147-151.
7. Wilson, J. D. and H. A. Runnels. 1934. Influence of Bordeaux and oil sprays on the daily curve of transpiration. *Ohio Agr. Exp. Sta. Bimo. Bull.* 19: 179-186.

color on leaf temperature, and accordingly on the transpiration rate, is negligible. As mentioned earlier, the color factor exerts its maximum effect on the rate of water loss from treated leaves only during periods of sunshine. Duggar and Cooley (5) found a number of materials (including lampblack) applied as sprays and dusts to increase the rate of water loss from plants over that from plants not treated. Runnels and Wilson (8) noted that the addition of lampblack to Bordeaux mixture increased the rate of desiccation of detached leaves over that of others treated with Bordeaux only. The authors have frequently observed instances in which plants sprayed with Bordeaux mixture lost less water during the period from 10 a. m. to 4 p. m. than similar but untreated plants. Also, in a few cases, even the 24-hour loss from sprayed plants has been smaller than that from untreated ones. This is more likely to happen with plants observed outdoors than in the greenhouse (9), since Bordeaux mixture usually causes a smaller increase in nighttime transpiration outdoors than inside. With these facts in mind an experiment was planned which would provide a further study of the influence of spray residue color on the transpiration rate.

### EXPERIMENTAL METHODS

The nature of this experiment made it desirable to conduct it in full sunlight and, thus, only on days which were as clear as could be expected at Wooster. To give the data obtained the maximum significance, it also seemed advisable to collect them simultaneously in full sunlight (direct plus indirect radiation) and under a suspended shade which would shut off direct sunlight, a method with which the senior author became familiar while assisting Livingston (10) in a study of the influence of solar radiation on transpiration. Livingston reported the influence of radiation on transpiration to be positive, and, since the principal modification made in his technique in the present experiment involved only the addition of spray residues of different absorptive capacities for impinging radiation, it should again be positive unless the residue present on the leaf sufficiently altered the normal response to make it otherwise.

The plants used in this study were grown in 1-gallon tinned cans, such as those described in previous work by the authors (6, 7, 9). Tests were made on coleus, bean, tomato, potato, tobacco, and cucumber. The 32 plants used in any particular trial were first carefully grouped in eight lots of four each. Each lot had the same transpirational capacity as each of the others, as determined over a 4-day period on a rotating table in the greenhouse. These eight lots were then divided into two groups of four each: four lots of four plants each to be placed in direct sunlight, and a similar series to be placed under a shade. This shade was about 4 feet wide and 8 feet long and was suspended about 8 feet above the ground by ropes fastened to each corner and passing through pulleys attached to the tops of poles about 16 feet tall. The shade could be raised, lowered, or tilted at will.

Three formulas of Bordeaux mixture were used to provide residues of the desired types. A 4-4-50 formula furnished the usual type; the quantity of lime was tripled to give a 4-12-50 formula with a decidedly light-colored but rather

8. Runnels, H. A. and J. D. Wilson. 1934. The influence of certain spray materials, herbicides, and other compounds on the desiccation of plant tissue. Ohio Agr. Exp. Sta. Bimo. Bull. 19: 104-109.

9. Wilson, J. D. and H. A. Runnels. 1934. Transpirational response of various plants to Bordeaux mixture. Ohio Agr. Exp. Sta. Bimo. Bull. 19: 198-202.

10. Livingston, B. E. 1923. Studies upon the influence of solar radiation on the rate of transpirational water loss from plants. Carnegie Inst. (Washington) Yearbook 22: 288-289.

opaque residue; and the dark one was prepared by adding lampblack at the rate of 4 pounds in 50 gallons to the 4-4-50 formula. These treatments were applied to two lots of four plants each, one in the sun and one in the shade series, and one lot in each was left untreated as a check to represent the normal condition. The two groups of 16 plants each were then placed on tables about 3 feet high. One of these was exposed to direct sunlight and the other was placed under the suspended shade. The plants were weighed individually at the time it was desired to start any given set of observations, usually at 6 or 9 a. m., and then at successive 3-hour intervals; the last weighing was made at either 3 or 6 p. m.

Since not more than half the days in summer are sunny at Wooster, a given lot of plants was usually kept in readiness over a period of a week before they were finally discarded, to insure the collection of data on at least two suitable days.

The relative evaporation and radiation values were determined by the use of black and white atmometers (11) attached to burettes and mounted on each of the tables. The air temperature was determined at each weighing interval from a thermometer in a near-by instrument shelter.

## RESULTS AND DISCUSSION

As mentioned previously, Tilford and May (3) found that the internal temperature of potato leaves was affected by the color of any spray residue they might bear. Their report suggested the advisability of determining the variations in the temperature of leaves bearing the different types of residue used in this experiment when the plants were placed in sun and shade. Although the authors realized the inaccuracy of the method, this was done by simply rolling the leaves around the elongated bulbs of specially selected thermometers, graduated in tenths of a degree Centigrade. The leaves were then held in place with a rubber band while the maximum temperature deviation, above or below the prevailing air temperature, was observed. This work was done between 9 a. m. and 3 p. m. in all instances. Leaves in the sun were protected temporarily from direct sunlight by a small shield while a determination was being made. A large number of readings, involving all four plants, was made for each treatment, both in sun and shade, and the average values are shown in Table 1.

TABLE 1.—Leaf Temperatures (°C.) of Various Plants Treated with Different Bordeaux Mixture Formulas and Placed in Direct Sunlight and Under a Shade

Treatments	Coleus		Tobacco		Cucumber		Average	
	Sun	Shade	Sun	Shade	Sun	Shade	Sun	Shade
Air temperature .....	39.2	36.0	32.6	26.9	28.8	23.7	33.5	28.9
Untreated .....	39.2	35.5	32.6	27.5	28.8	23.4	33.5	28.8
Bordeaux (4-4-50) .....	39.3	35.5	32.4	27.0	28.5	23.6	33.5	28.7
Bordeaux (4-12-50) .....	38.6	35.4	31.8	27.0	28.2	23.4	33.0	28.6
Bordeaux plus lampblack .....	41.1	35.7	34.6	27.9	31.7	24.1	35.8	29.9

All leaves, treated or untreated, were found to be warmer than the air when the plants were in full sunlight, which agrees with observations made by Curtis using a much more dependable method of leaf temperature measurements (12).

11. Livingston, B. E. 1935. Atmometers of porous porcelain and paper, and their use in physiological ecology. *Ecology* 16: 438-472.

12. Curtis, O. F. 1936. Leaf temperatures and the cooling of leaves by radiation. *Plant Physiol.* 11: 843-864.

Leaves bearing the residue of a 4-4-50 Bordeaux mixture were similar in temperature to untreated ones, both in sun and shade. Leaves which had been sprayed with the distinctly whiter 4-12-50 formula were from 0.2 to 1.0° C. cooler than those bearing no residue, when both groups were in the sun. In the shade the temperatures were similar. Leaves of plants sprayed with the 4-4-50 plus lampblack mixture and placed in the sun were from 2 to 5° C. warmer than those bearing the 4-4-50 residue only. Leaves of plants shaded from direct sunlight were usually at, or only slightly below, the temperature of the surrounding air and, thus, from 3 to 5° C. cooler than similar leaves on plants in full sunlight. This reduction in leaf temperature was brought about, as will be shown later, by a reduction in total radiation of approximately 65 per cent. The temperatures of leaves bearing the three different spray residues were in the same relative order under the shade as in the sun, but the difference between any two treatments was much less in the former than in the latter situation. Also, the leaves of the sprayed plants, as well as those of untreated ones, were consistently cooler in the shade, as would be expected. The average temperature differences between leaves in sun and shade were 4.7° C. when untreated and 4.8, 4.4, and 6.4° C. for 4-4-50, 4-12-50, and 4-4-50 plus lampblack treated plants, respectively. Thus, the sun and shade difference was least for the plants bearing the light-colored 4-12-50 residue and greatest for those receiving the lamp-black treatment.

Various preliminary experiments conducted in the greenhouse, previous to the spring of 1934, gave the authors a hint of what the effect of adding lamp-black to Bordeaux mixture might be on the rate of water loss from plants to which it was applied (8). The results of one trial conducted over a 4-day period in May in the greenhouse, where the radiant energy factor was approximately 50 per cent of the outdoor value (13), are shown in Table 2. The formulas used are indicated in the column headings. Lampblack was added to the 3-4½-50 Bordeaux mixture at the rate of 3 pounds in 50 gallons. Losses from black and white atmometers are included to show the effect of sunlight on evaporation during the period of the experiment (11). This is specifically indicated in the column headed B—W.

**TABLE 2.—Comparative Transpiration of Coleus Bearing Different Spray Residues on the Upper Side of the Leaves Only**

Data obtained in greenhouse with plants on a rotating table. 4-day averages

Time of day	No treatment	3-4½-50	3-9-50	3-4½-50 plus lamp-black	Effect of lamp-black	Atmometer		
						Black	White	B—W
	Gm.	Gm.	Gm.	Gm.		C. c.	C. c.	C. c.
1 p. m. to 7 a. m.	6.5	25.9	28.2	27.1	1.2	10.0	9.0	1.0
7 a. m. to 10 a. m.	43.4	44.5	44.0	52.1	7.6	6.8	4.0	2.8
10 a. m. to 1 p. m.	65.0	63.6	62.8	74.2	10.6	11.4	7.8	3.6
1 p. m. to 4 p. m.	50.6	49.2	48.0	55.2	6.0	8.8	6.5	2.3
4 p. m. to 7 p. m.	27.8	25.6	27.1	28.4	2.8	5.3	4.0	1.5
24-hour total	193	209	210	238	27.2	42.3	31.3	11.0

In a previous paper (6), it was noted that Bordeaux mixture was more effective in increasing transpiration from coleus plants when applied to the under sides of the leaves than to the upper. It was also observed that any

13. Wilson, J. D. 1937. Evaporation studies. I. A summary of evaporation and light values in greenhouses. Ohio Agr. Exp. Sta. Bimo. Bull. 22: 87-97.

increase due to a given treatment was greater on cloudy than on clear days. In the experiment now under discussion we were purposely dealing only with sunny days and with residues on the upper side of the leaves. Since there are few or no stomata on the upper side of the coleus leaf, any effect which a spray residue applied there may have in altering the transpiration rate must be due to an alteration of the cuticle or a change in the temperature of the leaf. Lampblack by itself probably has little effect on the leaf cuticle and thus any increase in transpiration which it brings about must be due to an increase in leaf temperature (3, 5). The data of Table 1 indicate that outdoors, at least, this temperature increase may be considerable between 9 a. m. and 3 p. m. Plants treated with Bordeaux mixture plus lampblack lost more water during each of the 3-hour periods of daylight than did those bearing Bordeaux only, as is indicated in column five of Table 2. The difference in effect between the two materials was greatest when the sunlight factor was at its maximum value (see B—W values in the last column of Table 2). It is interesting to note that the plants treated with the 3-9-50 formula lost but little more water than those receiving the 3-4½-50 formula and that although they lost more during the night period than the latter, they lost somewhat less than the 3-4½-50 group during the hours of maximum sunlight intensity.

A number of experiments similar to the one reported in connection with the data of Table 2 were later conducted outdoors with plants placed in full sunlight and under a shade. The plants were weighed each hour from 6 a. m. to 6 p. m., inclusive, and evaporation and air temperature data were collected for the same intervals. Some of the results obtained in one of these studies on coleus are shown graphically in Figure 1, and an arrangement of the data according to 3-hour totals is given in Table 3.

TABLE 3.—Transpiration of Coleus at Different Periods of the Day  
When Bearing Spray Residues with Different Capacities  
for Absorbing Radiant Energy

Average of 3 days in July

Time of day	Sun				Shade			
	No treat- ment	Bordeaux mixture			No treat- ment	Bordeaux mixture		
		4-4-50	4-12-50	4-4-50 plus lampblack		4-4-50	4-12-50	4-4-50 plus lampblack
	Gm.	Gm.	Gm.	Gm.	Gm.	Gm.	Gm.	Gm.
6 a. m. to 9 a. m. ....	76	85	74	97	41	46	53	49
9 a. m. to noon .....	141	150	135	165	113	111	111	124
Noon to 3 p. m. ....	168	175	165	195	139	136	142	151
3 p. m. to 6 p. m. ....	144	145	142	148	93	93	95	104
Total .....	529	555	516	605	386	386	401	428
Evaporation in c. c. ....	6-9	9-12	12-3	3-6	6-9	9-12	12-3	3-6
Black atmometer ....	9.6	19.5	23.9	21.0	6.4	13.6	18.0	17.1
White atmometer ....	6.0	14.3	18.7	17.5	4.5	11.6	15.6	15.0
B-W .....	3.6	5.2	5.2	3.5	1.9	2.0	2.4	2.1
Temperature, °C. ....					24.5	31.5	34.8	33.6

An examination of Figure 1 and Table 3 indicates that lampblack was much more effective in increasing the transpiration rate over that of untreated plants in the sun than in the shade. This was to be expected, since the radiant energy

factor (B—W) was less than half as great in the shade as in the sun during much of the day. During the period from 3 to 6 p. m. the losses from all groups of plants in the sun were similar, regardless of treatment, and the difference between the plants bearing the blackened residue and those not treated was at a minimum at that time, as may be seen in Figure 1. Differences between differently treated plants were relatively greatest during the period from 6 to 9 a. m., although sunlight intensity had not yet reached a maximum at 9 a. m. This suggests that the plants were most responsive during the early part of the day to those factors which tended to increase their rate of water loss. The ability of the comparatively white residue of a 4-12-50 Bordeaux mixture to reflect radiant energy caused the plants treated with this to lose less water than the other groups, when all were in full sunlight. In the shade, where total radiant energy was considerably less, the effect of the 4-12-50 treatment on transpiration was decreased, with the result that it was overbalanced by the opposite effect of the large amount of lime and, as a result, plants bearing this heavy residue lost more water than those not treated or those which bore the residue of the 4-4-50 formula.

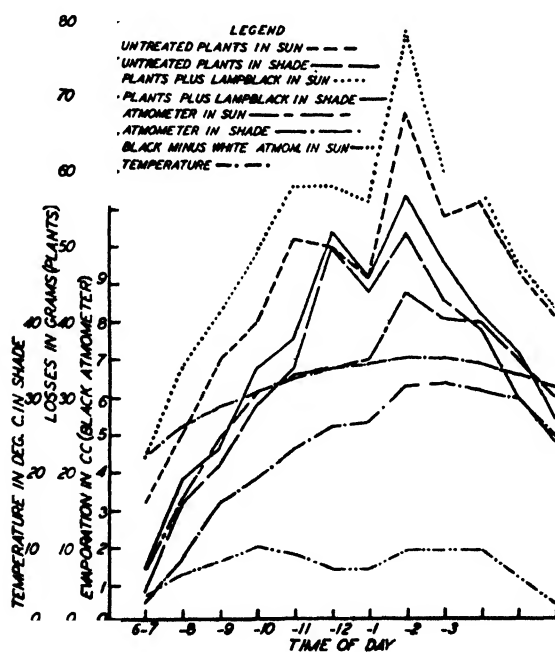


Fig. 1.—Comparison of average hourly transpiration from untreated plants, plants treated with Bordeaux mixture plus lampblack, and evaporation from black atmometers, when placed in full sunlight and under a shade. Comparative sunlight intensities are indicated by black minus white atmometer losses (B—W). Shade temperatures ( $^{\circ}$ C.) are shown for hourly intervals.

This is evident in some of the following tables, also.

As may be seen by an inspection of Figure 1, the graphs representing evaporation, temperature, and transpiration are of the same general form, with the values for all instruments and plants at a minimum for the hour from 6 a. m. to 7 a. m. and at a maximum somewhere between 1 p. m. and 4 p. m. The losses from both plants and atmometers turn rapidly downward in the late afternoon. Temperature falls less slowly. The graphs representing evaporation from the black atmometers follow the temperature line more closely than do the plants and in doing this they show the maximum evaporation and temperature values to occur somewhat later in the day than those for transpiration. This is the general experience in data of this kind.

An inspection of the comparative water losses from the plants of the shade and sun series shows that the former lose 55, 77, 82, and 66 per cent as much water as the latter from 6 to 9, 9 to 12, 12 to 3, and 3 to 6 o'clock, respectively. If the losses from untreated plants are compared in this manner, the values are 54, 80, 83, and 64 per cent, respectively. The variations are smaller for the plants receiving the 4-4-50 material and this plus lampblack. Since the 4-12-50 mixture tends to decrease transpiration in the sun and increase it in the shade, a comparison similar to those made for the other treatments gives values of 72, 82, 86, and 66 per cent as much loss in shade as in full sunlight for the hours from 6 to 9, 9 to 12, 12 to 3, and 3 to 6, respectively. Corresponding losses from black atmometers in sun and shade were 69, 70, 76, and 80.

The influence of the usual spray materials on the transpiration in sun and shade of coleus, cucumber, and tobacco from 6 a. m. to 6 p. m. is shown in Table 4 in a manner similar to that of Table 3. The corresponding values for evaporation are also given. In the sun the water loss from the untreated plants was equal to or greater than that from plants bearing the 4-4-50 or 4-12-50 Bordeaux formulas. The residue produced by the addition of lampblack to the spray material was again capable of causing a considerable increase in transpiration in the sun and somewhat less in the shade. The high-lime Bordeaux (4-12-50) also caused a water loss in the shade in excess of that from untreated plants. Cucumber and tobacco were affected by the spray materials used in much the same degree as was coleus. The night losses from cucumber are shown in the last column of Table 4; all the sprays caused a loss considerably in excess of that from untreated plants.

TABLE 4.—Transpiration of Coleus, Cucumber, and Tobacco from 6 a. m. to 6 p. m. in Sun and Shade When Treated with Various Materials

Treatment	Coleus		Cucumber		Tobacco		Night (6 p. m. to 6 a. m.) losses from cucumber
	Sun	Shade	Sun	Shade	Sun	Shade	
	Gm.	Gm.	Gm.	Gm.	Gm.	Gm.	Gm.
No treatment .....	139	97	84	60	138	86	67
Bordeaux (4-4-50) .....	134	96	84	66	139	85	92
Bordeaux (4-12-50) .....	127	100	85	68	137	87	95
4-4-50 plus lampblack .....	151	107	103	79	157	93	95
	C. c.	C. c.	C. c.	C. c.	C. c.	C. c.	C. c.
Evaporation							
Black .....	74.0	53.1	45.0	28.3	58.1	42.2	10.8
White .....	56.5	46.7	31.7	24.5	39.1	34.9	10.5
Temperature, °C .....		22.2		22.0		23.2	

The tests, which were, as previously described, conducted with a group of 32 plants, were repeated a number of times with coleus and tomato during the summers of 1934 and 1935. Some of the data were collected from 6 a. m. to 6 p. m. at hourly or 3-hour intervals, and in other instances the weighings were made only at 9 a. m., noon, and 3 p. m. Table 5 presents a summary of data collected on 14 different days for coleus and 10 for tomatoes. A number of different groups of test plants were used for both kinds of plants. The average losses from black and white atmometers on the same days are also given, as well as the average temperatures in the shade.

TABLE 5.—Influence of Spray Residue on Transpiration of Coleus (Average 14 Days) and Tomato (Average 10 Days) in Sun and Shade from 9 a. m. to 3 p. m.

Treatment	Coleus		Tomato	
	Sun	Shade	Sun	Shade
	Gm.	Gm.	Gm.	Gm.
No treatment.....	175	97	191	116
Bordeaux (4-4-50).....	173	100	188	117
Bordeaux (4-12-50).....	170	100	185	119
4-4-50 plus lampblack.....	189	111	208	127
	C. c.	C. c.	C. c.	C. c.
Evaporation				
Black.....	33.4	23.7	32.0	23.0
White.....	23.4	20.2	21.0	17.9
B-W.....	10.0	3.5	11.0	4.1
Temperature, °C.....		25.4		24.5

The coleus and tomato plants in the shade lost approximately 60 per cent as much water as those in the sun. The black atmometers lost about 70 per cent as much water in the shade as in the sun, in both instances. The sunlight values, represented as B—W, were only about 35 per cent as great in the shade as in the sun. This means that about one-third of the total radiant energy in full sunlight was made up of indirect radiation between the hours of 9 a. m. and 3 p. m. The two-thirds which was cut off by the shade was capable of increasing transpiration over that in the shade by about 72, 68, 63, and 68 per cent for the untreated plants and those bearing the 4-4-50, 4-12-50, and blackened residues, respectively. The relative transpiration (14) (transpiration divided by evaporation from the black atmometer in this instance) was 5.6 in the sun and 4.6 in the shade for the untreated plants. The values became 6.2 in the sun and 5.1 in the shade for the plants treated with Bordeaux mixture plus lamp-black. These values of relative transpiration indicate that the treated and untreated plants responded very similarly to the difference in radiant energy existing between the sun and shade environments and that evaporation was reduced less than transpiration by shading.

Untreated plants of both coleus and tomato lost more water outdoors in the sunlight between the hours of 9 a. m. and 3 p. m. than did those receiving either a 4-4-50 or a 4-12-50 Bordeaux. Similar results have previously been noted in the greenhouse (6) for the same hours. Plants bearing the highly reflective residue of the 4-12-50 formula lost the least water in sunlight and those bearing

the blackened residue with its high absorptive capacity for radiant energy had the highest transpiration rate, as was noted in the discussion of the data of Table 3. Under the shade, with its decrease in radiant energy values, all the groups of treated plants transpired more rapidly than the untreated. The whiter but heavier residue of the 4-12-50 formula again caused a slightly greater water loss from the plants treated with it than took place from those which received the 4-4-50 preparation. Also, the blackened residues again caused the greatest increase in transpiration, particularly for the plants in full sunlight.

In Table 6 transpiration data for the midday period are shown for cucumber, tobacco, bean, and potato. These data are less consistent on the influence of the different spray mixtures on transpiration than most of those dealing with coles and tomato. However, the plants treated with Bordeaux plus lamp-black lost more water in both sun and shade than did any of the others, treated or untreated.

TABLE 6.—Comparative Transpiration in Sun and Shade of Plants Treated with Different Bordeaux Mixture Formulas

Data for period from 9 a. m. to 3 p. m. on sunny days

Treatment	Cucumbers		Tobacco		Bean		Potato	
	Sun	Shade	Sun	Shade	Sun	Shade	Sun	Shade
	Gm.	Gm.	Gm.	Gm.	Gm.	Gm.	Gm.	Gm.
No treatment.....	105	73	187	100	75	51	227	128
Bordeaux (4-4-50).....	109	85	180	97	71	47	215	123
Bordeaux (4-12-50).....	120	84	178	98	68	49	201	122
4-4-50 plus lampblack.....	132	96	209	111	75	51	231	140
	C. c.	C. c.	C. c.	C. c.	C. c.	C. c.	C. c.	C. c.
Evaporation								
Black.....	28.9	19.0	27.2	17.4	34.8	22.8	31.5	20.1
White.....	19.9	16.1	16.8	13.8	23.3	19.3	18.7	16.4
Temperature, °C.....		21.7		21.3		26.1		25.9
Relative transpiration								
Untreated plants.....	3.6	2.3	6.9	5.7	2.1	2.2	7.2	6.4
Black atmometer								

The relative transpirations of untreated plants and the black atmometer were similar in sun and shade. They were somewhat lower in the shade than in the sun for cucumber and bean, and the reverse was true for tobacco and potato. It seems unlikely, however, that much importance can be attached to these variations in this ratio for the different species listed. The results obtained with bean and potato were not entirely satisfactory because of rather wide differences in the behavior of individual plants during the trial periods.

## SUMMARY

Bordeaux mixture affects the temperature of leaves to which it is applied, particularly during periods of sunshine. Since such a change alters the vapor pressure gradient between the leaf and the air surrounding it, the transpiration rate is also affected. Although the ultimate effect of Bordeaux mixture is to increase the rate of water loss of plants to which it is applied, transpiration may actually be decreased in sunlight, if the residue reflects a sufficient portion of

the radiant energy striking the leaf so that it is cooled below the air temperature. The addition of lampblack to the Bordeaux increased the temperature of treated leaves to a point above that of the air; whereas an excess of lime in the spray mixture had the opposite effect. The influence of radiation on transpiration was known to be positive and with this in mind it was decided to study the relation of spray residues of different reflective capacities to the transpiration rate in sun and shade. The spray formulas used were a 4-4-50 and a 4-12-50 Bordeaux mixture and a combination of the 4-4-50 formula and lampblack used at the rate of 4 pounds of lampblack in 50 gallons. Evaporation from black and white atmometers was also determined to give a measure of sunlight intensity in sun and shade. Air temperatures in the shade were also available.

Leaf temperature determinations showed the leaves of all plants to be warmer than the air when in full sunlight. Leaves bearing the 4-12-50 residue were cooler than untreated ones; whereas those treated with the lampblack mixture were warmer. The 4-4-50 residue had little effect on leaf temperature. The leaves of plants in the shade were usually slightly cooler than the air, with the exception of those bearing the lampblack-containing residue, and were from 2 to 5° C. cooler than comparable ones in the sun.

In the greenhouse, where the radiant energy factor was only about 50 per cent of full sunlight, transpiration was decreased by the presence of the residues from a 3-4½-50 and 3-9-50 Bordeaux mixture but increased by a 3-4½-50 plus 3 pounds of lampblack, between the hours of 10 a. m. and 4 p. m. The effect of lampblack on transpiration was at a maximum during the period of maximum sunlight intensity, i. e., from 10 a. m. to 1 p. m.

Lampblack added to Bordeaux mixture was more effective in increasing the transpiration rate of plants in full sunlight than in the shade, where the radiant energy values were less than half as great. This was due to the ability of the blackened residue to absorb a large amount of the radiant energy striking it in full sunlight. On the other hand, the reflective power of the comparatively white residue of a 4-12-50 Bordeaux mixture caused plants bearing it to lose less water in full sunlight than any of the other groups.

The transpirational responses of all the species tried (coleus, tomato, cucumber, tobacco, bean, and potato) to the different sprays used were similar but, of course, not equal. Cucumber and tobacco were affected much as coleus; tomato was slightly less responsive; and the data for beans and potatoes were more variable and thus not as conclusive as the rest. In a summary of the data from 14 trials with coleus and 10 with tomatoes, from 9 a. m. to 3 p. m. only, the plants in the shade were found to lose approximately 60 per cent as much water as those in full sunlight. Black atmometers in the shade lost 70 per cent as much as those in the sun in the same experiments. Sunlight intensities, as measured by the difference in water loss from black and white atmometers, were 35 per cent as great in the shade as in the sun. Cutting off two-thirds of the radiant energy by a shade reduced the average transpiration rates in the sun by about 42, 40, 39, and 40 per cent for untreated plants and those bearing the 4-4-50, 4-12-50, and blackened residues, respectively. Relative transpiration for the untreated plants was 5.6 in the sun and 4.6 in the shade, indicating that evaporation was reduced less than transpiration by shading.

# FROST INJURY TO RASPBERRY FLOWER BUDS

LEON HAVIS

Late spring frost or freezing injury to raspberry flower buds is not common in Ohio. Nevertheless, on May 12, 1938, many varieties were severely injured by frost. As near as can be determined, this frost of May 12 was the most detrimental one since the Experiment Station was established at Wooster in 1894. It is not unusual for frost to occur as late as this, but it is unusual for raspberries to be as far advanced as in 1938. Evidently the flower buds were 12 to 15 days more advanced than usual. The partial destruction of the flower buds by frost offered an unusual opportunity to secure information on this type of injury, especially on the relative resistance of some of the newer varieties.

It is emphasized that it is unusual for such a severe frost as the one here reported to occur after the raspberry buds are as far advanced as in this season (1938). It is not meant to imply that the choice of varieties should be based on their relative spring frost resistance. Other factors, such as resistance to diseases, yield, quality, size, firmness, and market value, are more important from a commercial standpoint.

## PLANTS AND METHODS USED

Thermographic records taken within 300 feet of the black raspberry planting and within 500 feet of the reds showed that the temperature reached 32° F. at about 4:00 a. m. on May 12, 1938. They showed that it remained below 32° F. for about 4 hours, from 4:00 a. m. to 8:00 a. m. The temperature was below 30° F. during 2 of these hours, from 4:30 a. m. to 6:30 a. m. The minimum temperature recorded here was 29° F., although it was probably lower than that in some sections of the orchard.

Both the red and black raspberry variety plantings were set out in the spring of 1936. There were 75 plants of each black raspberry variety, and each one was systematically distributed through the planting into 3 rows of 25 plants each. About the same system was followed in the red raspberry planting. In this study 8 black and 10 red raspberry varieties were used. The standard varieties in Ohio, as well as some of the most promising newer ones, were included.

Raspberry flower buds are produced on the current season's shoots (as terminal cymes) and also in small clusters in the axils of several of the leaves nearest the terminal inflorescence. The more vigorous shoots usually produce the most lateral buds. Furthermore, varieties vary considerably in the number of these lateral flower clusters formed (Table 1). The frost injury data (Table 1) were secured by obtaining the percentage of flower buds killed: (a) in the terminal cyme, and (b) in the terminal cyme and the lateral clusters. In each case at least 100 flower buds of specimens selected at random in each variety were used. In most cases a larger number of buds were examined, but it was found that 100 were sufficient for this study.

## RESULTS

There was no frost injury on May 12, 1938, to the flower buds of most red raspberry varieties examined. The Lloyd George, which lacks resistance to winter temperatures in Ohio, seemed most affected. A small number of the flower buds of the Chief and June varieties were also killed. The amount of injury to these two early red varieties, which were just beginning to blossom, was extremely small, and negligible from the standpoint of potential yield.

The black raspberry flower buds were much more severely injured by the late frost than were the reds. All the black varieties in the test plots were affected. The buds of the earlier varieties were most advanced at the time of the frost and were, as a whole, most severely injured. This may be exemplified by the relatively severe injury of Logan and Plum Farmer; whereas Naples and Quillen showed least injury (Table 1). There were, however, some exceptions to this rule. Although Bristol ripens slightly earlier than Cumberland, there was less injury to the former variety. This was especially true when all (terminal and lateral) flower clusters on the shoot were included (Table 1).



Fig. 1.—Current season's shoot of Cumberland black raspberry, showing arrangement of flower clusters and stage of development at the time of the frost on May 12, 1938

The flower buds of the Black Beauty and Cumberland seemed to be in the same stage, and the fruit ripens at the same time, but the frost injury to Cumberland was more severe in the terminal clusters. The Black Beauty produced relatively few lateral flower clusters; hence when all buds on the shoots were included, the Black Beauty was found to be injured most. The Dundee also produces relatively few lateral

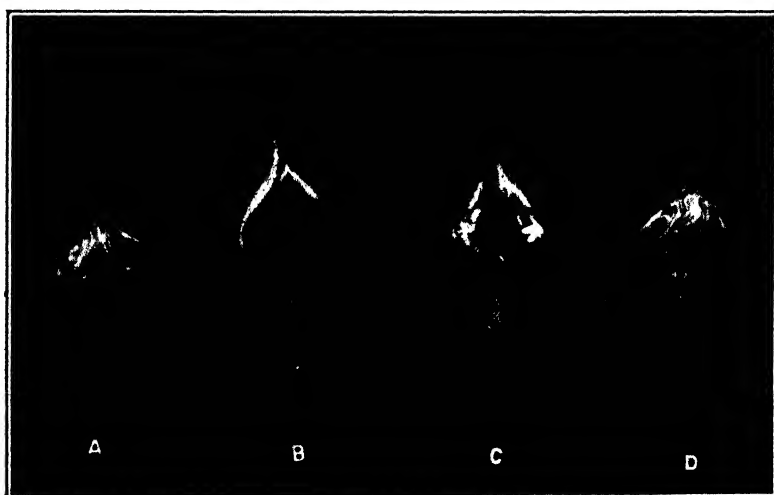
buds; thus there was little difference between the percentage injured when only the terminal cluster was examined and when the lateral buds were included. The Naples and Quillen showed about the same amount of injury in the terminal clusters, but, since there were more lateral flower clusters along the shoots of the Naples, the total percentage of Naples killed was less. A larger percentage of the flower buds of Plum Farmer than of Logan are borne in lateral clusters; hence the total percentage of Plum Farmer buds surviving the frost was greater.

**TABLE 1.—The Relative Amount of Frost Injury to the Flower Buds of Some Black Raspberry Varieties**

Variety	Terminal cluster (per cent dead)	Terminal clusters plus lateral clusters (per cent dead)	Relative number of lateral flower clusters
Black Beauty .....	44	41	few (2 to 5)
Bristol .....	52	28	many (6 to 9)
Cumberland .....	56	36	several (4 to 7)
Dundee .....	30	26	few (2 to 5)
Logan (New Logan) .....	73	71	few (2 to 5)
Naples .....	39	30	several (4 to 7)
Plum Farmer .....	68	50	many (6 to 9)
Quillen .....	38	34	very few (0 to 3)

**TYPES OF FLOWER BUD INJURY**

The most common type of injury to the raspberry flower buds was the killing of both the pistil and the stamens (Fig. 2, B). There were other types of injury, however. In securing these data the flower bud was recorded as killed when the pistil was injured, regardless of the condition of the stamens. In 8 to 10 per cent of those recorded as dead the stamens were not all injured. A few flowers were examined in which the pistil was dead and all stamens were alive (Fig. 2, C). This type was fairly common in the red varieties, such as Lloyd George, June, and Chief. Another type of injury, although rare, was found in which the pistil was alive and all stamens were dead (Fig. 2, D). Buds with this type of injury were recorded as alive, since they may be pollinated by pollen from stamens of other flowers. The petals of the black raspberries seemed as tender as any other flower part, since they were usually killed when any other part was even slightly injured. The pistils of the red raspberries were usually killed before any injury was shown in the petals.



**Fig. 2.—Representative types of raspberry flower bud injury observed in the Cumberland variety following severe frost. A, uninjured; B, pistil and stamens dead; C, pistil dead and stamens alive; D, pistil alive and stamens dead**

# NO PRUNING COMPARED WITH LIGHT AND HEAVY PRUNING OF APPLE TREES

C. W. ELLENWOOD AND J. H. GOURLEY

Some observations and data on different types of pruning of apple trees are presented here. The varieties in this experiment are Baldwin and Stayman Winesap trees planted in 1916. Data are presented in Table 1 on size and color grades for 4 full crop years of each variety. The records for the light crop years have also been taken and are shown in Table 2. However, since color and size of fruit are more nearly normal in the full crop years, the data taken those years are mainly considered in this report. The records for the Baldwin trees shown in Table 1 are for 4 years, including 1931, 1933, 1935, and 1937. Those for Stayman are for 1930, 1932, 1934, and 1936.

TABLE 1.—Influence of Degree of Pruning on Size and Color  
Baldwin and Stayman

4-year average								
Variety	Pruning treatment	Size grade			Color grade			Average annual yield per tree 4-year average
		Above 2½ inches	2½ to 2¾ inches	Below 2¾ inches	Above 33 per cent	15 to 33 per cent	Below 15 per cent	
		<i>Pct.</i>	<i>Pct.</i>	<i>Pct.</i>				<i>Lb.</i>
Baldwin.....	Not pruned	81.7	15.4	2.9	65.0	16.5	18.5	521
Baldwin.....	Light	92.5	7.2	0.3	81.8	12.8	5.4	405
Baldwin.....	Heavy	93.5	6.2	0.3	87.9	9.4	2.7	376
Stayman.....	Not pruned	68.7	28.9	2.4	66.8	19.5	13.7	581
Stayman.....	Light	82.9	16.5	0.6	78.0	14.7	7.3	552
Stayman.....	Heavy	85.3	14.4	0.3	81.2	14.8	4.0	372

TABLE 2.—Average Annual Yield of Baldwin and Stayman in Alternate Heavy and Light Crop Years

4-year averages				
Variety	Pruning treatment	Average annual yield per tree full crop years 4-year average	Average annual yield per tree light crop years 4-year average	Average annual yield per tree for 8-year period 1930-1937
Baldwin.....	Not pruned	521	377	449
Baldwin.....	Light	405	241	323
Baldwin.....	Heavy	376	289	333
Stayman.....	Not pruned	581	364	473
Stayman.....	Light	552	391	472
Stayman.....	Heavy	372	158	265

In addition to a block of trees which have not been pruned since they were planted, there are two other blocks of trees which have been given (a) light annual pruning and (b) heavy annual pruning.

On the light pruned plot the pruning has consisted of a light thinning out of branches and only sufficient restriction of terminal growth to preserve a fair degree of symmetry of tree.

On the heavy pruned plot the same general type of pruning as practiced on the light pruned plot has been done. In the earlier years heavier cuts were made in pruning the heavy pruned plot than on the light pruned plots, and there are fewer small lateral fruit bearing branches on the heavy pruned trees. During the growing season the heavy pruned trees appear to be considerably less dense in foliage than the adjacent light pruned plot. The total weight of prunings removed from the two plots has been about the same.

During the life of this orchard growth measurements have been taken at different intervals. Table 3 shows the size of the trees at the end of the twenty-second growing season. The diameter of the head of the tree is the average of two measurements made on each tree. The circumference shown in Table 3 was taken around the trunk 12 inches above the ground.

TABLE 3.—Influence of Pruning on Size of Trees 22 Years after Planting

Variety	Pruning treatment	Diameter of head	Height	Circumference
		<i> Ft. </i>	<i> Ft. </i>	<i> In. </i>
Baldwin.....	Not pruned	28.7	21.7	43.9
Baldwin.....	Light	25.0	21.8	36.3
Baldwin.....	Heavy	25.8	20.5	36.2
Stayman.....	Not pruned	24.4	22.5	34.2
Stayman.....	Light	24.5	22.2	34.4
Stayman.....	Heavy	21.3	20.0	31.2

Fertilizer and spray treatments have been identical on all three plots throughout the life of the orchard. The trees at all times have given evidence of being in good vigor.

### WHAT THE DATA SHOW

The results of this experiment show that pruning, either heavy or light, reduced the yield per tree with both varieties (Table 1). With Baldwin the yield of the light pruned trees was reduced by more than 22 per cent; whereas the yield of the heavy pruned Baldwin plot was 28 per cent less than that of the unpruned plot. The yield per tree on the light pruned Stayman plot was 5 per cent less than that of the unpruned plot and the heavy pruned Stayman plot had an average per tree yield of 34 per cent less than the unpruned trees.

The varieties responded differently to the pruning treatments. Light pruning reduced the yield of Stayman but 5 per cent; whereas the yield per tree on the light pruned Baldwin plot was 22 per cent less than that on the unpruned plot. Light pruning improved the size of Stayman more than Baldwin (Table 1). Color responses from pruning were very similar with both varieties.

The dwarfing of the trees due to pruning was also more apparent with Baldwin than with Stayman (Table 3).

When the value of the fruit per tree for the three plots is considered (Table 4), it will be seen that only in the case of the light pruned plot was there any increase in value of fruit as the result of pruning and even here, if the cost of pruning were deducted from the value of the fruit on the light pruned plot, the margin in favor of the light pruned plot would be narrow. The cost of pruning and removing the brush was approximately 30 cents per tree annually.

**TABLE 4.—Influence of Pruning on Value of Fruit per Tree**  
Baldwin and Stayman

Variety	Pruning treatment	Commercial grade			Value of fruit per 100 pounds	Average annual yield per tree	Average annual value per tree
		No. 1	No. 2	Culls			
		<i>Pct.</i>	<i>Pct.</i>	<i>Pct.</i>	<i>Dol.</i>	<i>Lb.</i>	<i>Dol.</i>
Baldwin.....	Not pruned	53	28	19	1.17	521	6.10
Baldwin.....	Light	76	18	6	1.35	405	5.47
Baldwin.....	Heavy	82	15	3	1.40	376	5.26
Stayman.....	Not pruned	46	40	14	1.16	581	6.74
Stayman.....	Light	65	28	7	1.29	552	7.12
Stayman.....	Heavy	69	27	4	1.33	372	4.95

The value of the apples as shown in Table 4 is based on a fair average net price for apples graded into three grades for the 4-year period. One and one-half cents per pound was allowed for the No. 1 grade; 1 cent per pound for the No. 2 grade; and ½ cent per pound for the culls.

Naturally a wider differential in price between the grades might materially alter the relationship in value of fruit on the three plots. A variety, such as Delicious, with a comparatively high price for the best grade of fruit would be able to tolerate a somewhat greater sacrifice of total yield per tree than a variety like Baldwin, which usually commands a lower price for top grades.

**TABLE 5.—Color and Size of Apples from Different Areas of Unpruned Trees**  
Record for single year's crop  
Baldwin (1937) Stayman (1936)

Variety	Pruning treatment	Size grade			Color grade		
		Above 2½ inches	2½ to 2¾ inches	Below 2¾ inches	Above 33 per cent	15 to 33 per cent	Below 15 per cent
		<i>Pct.</i>	<i>Pct.</i>	<i>Pct.</i>			
Baldwin.....	Not pruned, top of tree..	96.6	3.3	0.1	74.3	14.1	11.6
Baldwin.....	Not pruned, bottom of tree.....	93.1	6.6	0.3	38.8	21.1	40.1
Baldwin.....	Not pruned, inside of tree.....	87.7	11.9	0.4	39.6	15.6	44.8
Baldwin.....	Not pruned, average for entire tree.....	92.5	7.2	0.3	54.0	16.1	29.9
Baldwin.....	Light.....	93.3	6.7	0.0	78.8	14.1	7.1
Baldwin.....	Heavy.....	91.7	8.2	0.1	86.1	10.9	3.0
Stayman.....	Not pruned, top of tree..	47.0	47.8	5.2	77.5	13.3	9.2
Stayman.....	Not pruned, bottom of tree.....	40.8	55.2	4.0	64.3	20.3	15.4
Stayman.....	Not pruned, inside of tree.....	19.0	60.1	20.9	16.9	22.3	60.8
Stayman.....	Not pruned, average for entire tree.....	39.0	53.1	7.9	60.0	18.0	22.0
Stayman.....	Light.....	80.6	18.5	0.9	67.0	20.8	12.2
Stayman.....	Heavy.....	77.4	21.9	0.7	67.2	18.3	14.5

An improvement in color and size of fruit which is secured at the expense of too great a reduction in yield per tree may easily result in an actual financial loss to the orchardist. It must be recognized that the benefits derived from any orchard practice are determined by the effect of that practice on the value of the fruit per tree over a period of years.

As previously indicated, the yield records shown in Table 1 are for 4 full crop years. In Table 2 the average annual yield for the 4 alternating light crop years is shown along with the yield for the heavy crop years and average annual production in the entire 8-year period. There is little to indicate that pruning had any appreciable effect on the average annual production for the 8-year period when both heavy and light crop years are included. The average yield per tree of the Stayman on the light pruned plot during the light crop years exceeded that from the unpruned plot by 27 pounds. This is a comparatively small difference, but would tend to increase slightly the value of the fruit per tree of the light pruned as compared with the unpruned Stayman over the 8-year period.

### MINOR ADVANTAGES OF PRUNING

Some of the minor advantages to be expected from at least light pruning not measured here are:

1. Picking is facilitated.
2. The spray material required, theoretically at least, is somewhat greater on the unpruned trees, although actually there would be a comparatively insignificant difference in cost.
3. More thorough spraying is possible on pruned than on unpruned trees.

### CONCLUSIONS

A careful study of the data presented here shows that heavy pruning resulted in a serious loss in the value of fruit as compared with no pruning. Even light pruning of Baldwin actually reduced the value of the fruit per tree. Moreover, the margin of profit as the result of light pruning in the case of Stayman was so narrow as to make it insignificant.

Varieties respond differently to similar pruning treatments. The data here presented are rather limited both as to varieties and pruning treatments. It is not suggested that the orchardist follow a policy of no pruning.

Pruning generally represents from 8 to 10 per cent of the total growing costs of apples from mature trees, and if the process of pruning also reduces yield an appreciable amount, growers are warranted in scrutinizing this operation very carefully. Conventional pruning recommendations frequently have been made with little regard for the net results from an economic standpoint.

### COLOR AND SIZE OF APPLES FROM DIFFERENT AREAS OF UNPRUNED TREES

In 1936 an effort was made to secure some data as to the color and size of Stayman grown on different areas of the unpruned trees. The trees were separated into three sections and picked as follows: (a) The lower section of the tree up to a vertical height of 8 feet was picked first and designated as "lower section". (b) The top of the tree was next picked and designated "top section". (c) Finally the inside of the tree was picked and the fruit labelled "inside section".

The fruit was graded into three color grades: (a) above 33 per cent, (b) 15 to 33 per cent, and (c) below 15 per cent. The three size grades were (a) above 2½ inches, (b) 2¼ to 2½ inches, and (c) below 2¼ inches.

In 1937 the Baldwin fruits from the unpruned plot were picked and graded in the manner described.

The size and color grades of the fruit from the unpruned Baldwin plot for 1937 and from the unpruned Stayman plot for 1936 are shown in Table 5.

The grades are also shown for the fruit from the light and heavy pruned Baldwin plots for 1937 and for the light and heavy Stayman for 1936.

The total weights of Baldwin were as follows: top section, 639 pounds; lower section, 332 pounds; and inside section, 553 pounds. The Stayman weights were: top, 1031 pounds; lower, 970 pounds; and inside, 499 pounds. The comparative values of the fruit were: Stayman top, \$1.14; bottom, \$1.08; and inside, 85 cents per 100 pounds of fruit. For Baldwin the values were \$1.30, 99 cents, and 98 cents, respectively. The two varieties differed to some degree in that there was more fruit on the inside of the Baldwin trees, and that there was also a higher percentage of first color on the Baldwin from the inside of the tree than on the Stayman. A higher percentage of No. 1 fruit and more of it were borne in the top section of the tree than on the bottom or inside the tree.

The comparatively low grade of fruit, both as to color and size, on the inside of the tree, particularly of Stayman, suggests that much of the weak growth in the center of these unpruned trees might have been eliminated without much actual loss. The elimination of a few of the unproductive limbs on the inside section of the trees would have facilitated picking to a considerable degree.

## **BASAL METABOLISM AND FOOD INTAKE OF COLLEGE WOMEN**

**HUGHINA MCKAY AND MARY BROWN PATTON**

The results of a study of the food intake of a group of women students at the University of Chicago published in 1894 showed an average daily intake of 3277 calories and 108 grams of protein per individual. Since that time, studies which have been made show for college women a progressively lowered intake of calories and protein. There are probably two factors which account for the lower figures of later studies: (a) more careful methods of making dietary studies and (b) an actual lowered food intake of young women.

Basal metabolism figures form the foundation upon which the calorie requirements of the body must be based and are, therefore, of interest in connection with the actual food intake of individuals. For that reason a study was planned to include observations of the basal metabolism, as well as the calorie and protein intake, of college women to add to information concerning the three and to see if any relationship might be found between basal metabolism and calorie intake and basal metabolism and protein intake.

Eleven students majoring in home economics were selected as subjects. Four of the women were seniors, five were sophomores, and two were freshmen. All were carrying on their usual activities and all seemed to be in good physical

condition, although, as shown in Table 1, subjects II, III, X, and XI were decidedly underweight when compared to the Wood standards of weight in relation to age and height.

To determine the basal metabolism of the young women, the Benedict Roth Respiration Apparatus was used. Details of the method have been described elsewhere (1) and need not be repeated here.

For each subject, two observations were made on each day a test was run. If the results of the two observations agreed within 5 per cent, the average of the two tests was taken as the basal metabolism figure for that day. Tests were run on a second and in some cases a third day, and the final figure, therefore, represented an average of at least four observations. All observations were made during the intermenstrual periods.

TABLE 1.—Basal Metabolism and Food Intake of College Women

Subject	Number of observations	Age	Height	Weight	Basal metabolism		Food intake		
					Total calories	Calories per square meter per hour	Calories		Protein (total grams)
							Total	In excess of basal metabolism	
		<i>Yr.</i>	<i>Cm.</i>	<i>Kg.</i>					
I	6	23	167	56	1339	34	1485	146	41.06
II	4	22	162	41	1133	34	1435	302	54.88
III	6	21	161	49	1272	35	1969	697	58.81
IV	4	21	153	49	1281	37	2448	1167	82.75
V	4	20	154	54	1302	36	1119	183	53.19
VI	4	19	164	61	1434	36	1899	465	58.12
VII	4	19	173	67	1468	34	1959	491	73.06
VIII	4	19	163	56	1326	35	2568	1242	72.25
IX	4	19	164	57	1326	34	1988	662	69.88
X	6	19	155	43	1031	31	1834	803	47.25
XI	4	18	168	49	1173	32	1556	383	56.88

To obtain data concerning food intake of the group, each girl weighed all the food she ate during a period of 1 week. At each meal she also weighed a sample equivalent to one-tenth of the amount of food eaten. A composite sample, representing one-tenth of the food eaten during the week, was brought to the laboratory. Samples of each complete composite representing one-tenth of the week's food intake for one girl were dried. Calorie value of each composite sample was then determined by means of the oxy-calorimeter, and protein value, by the Kjeldahl method.

Table 1, giving the results of the study, shows the basal metabolism, as well as the calorie and protein intake, of each subject.

### BASAL METABOLISM

As shown by Table 1, with possibly two exceptions, the basal metabolism as expressed in heat production per square meter per hour varied little from individual to individual. Although only one of the girls had a basal metabolism equal to that of the Aub du Bois standard, probably none of the figures indicates abnormality, with the possible exception of Subject X. According to Talbot

(2), too much emphasis should not be laid on minor variations outside the commonly used plus or minus 10 per cent limit. In his opinion, variations of less than 17 per cent are probably insignificant.

The two subjects, X and XI, for whom lowest basal metabolism figures were found, were two who were also decidedly underweight. Subject II, however, with extreme underweight (26 per cent) had a basal metabolism well within the customarily accepted 10 per cent deviation.

In a study of the basal metabolism and food consumption of underweight college women, Blunt and Bauer (3) found no relationship between basal metabolism and underweight.

Figures of basal metabolism of 17 young college women as reported by Coons and Schiefelbusch (4) show no consistent relationship between heat production figures and underweight.

### CALORIE INTAKE

Average calorie intakes of the 11 young women showed considerable variation from subject to subject, ranging from a surprisingly low figure of 1119 to a high figure of 2568 calories with an average of 1842 daily. Of the 11 subjects, three had less than 1500 and only two had more than 2000 calories daily. In only five cases was the calorie intake sufficiently in excess of basal requirements to give assurance of adequate provision for muscular activity of the subjects.

Subject V, with the lowest calorie intake of the group and with a calorie intake below her basal requirements, was slightly overweight and appeared to have taken drastic dietary measures to overcome that condition. On the other hand, subject II, with the most extreme underweight of the group, had a calorie intake of only about 300 calories in excess of her basal requirements.

Girls having the higher calorie intakes averaged a somewhat higher basal metabolism than the others, but the differences were so slight as to be negligible.

### PROTEIN INTAKE

Protein intake ranged from 41 to 82 with an average of 61 grams daily. For all but two subjects, the protein intake exceeded the commonly accepted standard of 1 gram of protein per kilogram of body weight, and for these two subjects the intake was between  $\frac{2}{3}$  and 1 gram per kilogram of body weight. For these 11 young women, protein provision seemed adequate.

No consistent relationship between protein intake and basal metabolic rate was shown. However, the average protein intake of the two girls averaging the low basal metabolic rate of 32 calories per square meter was 52 grams daily as compared to an average protein intake of 63 grams for the nine women averaging a basal metabolism of 35 calories per square meter per hour.

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2. Talbot, F. B., E. W. Wilson, and J. Worchester. 1935. *The Journal of Pediatrics* 7: 55.
  3. Blunt, K. and V. Bauer. 1922. *Journal of Home Economics*. 14: 171.
  4. Coons, C. M. and A. T. Schiefelbusch. 1932. *Journal of Nutrition*. 5: 459.

In conclusion it may be repeated that with two exceptions the basal metabolism of this small group of college women varied little from subject to subject when expressed on the basis of surface area. Calorie intake varied greatly. Of 11 women, only five appeared to be having enough calories to assure adequate provision for muscular activity. In all but two cases protein intakes were equal to or greater than 1 gram of protein per kilogram of body weight; therefore probably adequate protein intake was assured.

## FACTORS CAUSING VARIATIONS IN MILK RETURNS

C. G. McBRIDE

The distinction between the quoted price for milk and producers' average returns is not generally understood. In city markets the price is quoted upon the basis of 100 pounds of milk of a specified base test (usually 3.5 per cent butterfat in northern Ohio, and 4.0 per cent in central and southern Ohio) delivered at the receiving platform of the dealer's plant. The average return per hundredweight for all milk sold during a year is the best basis of calculating income from milk sales.

Table 1 gives the average returns at the farm for milk at the actual test delivered and the computed value at the base test for both the farm and dealer's platform of a group of 56 farmers who kept farm account records in a county in northern Ohio for the calendar year 1936.

The average returns for the year at actual test were computed by adding together gross receipts for the 12 months, subtracting trucking charges, and dividing this sum by the total pounds sold. This figure represents actual returns from milk at the farm. Variations in this column arise from the following factors.

**Prevailing market prices.**—The milk from these 56 farms was sold to 23 dealers in four different markets, Cleveland, Akron, Medina, and Lodi. There were wide variations in the prices quoted from month to month for milk of base test by these 23 dealers.

**Butterfat content.**—The range in returns resulting from varying monthly tests of butterfat are given in Table 1. It must not be assumed, however, that these figures of average returns per hundredweight are an exact measure of net profitableness of the dairy enterprise upon these farms, because there are differences in costs of producing milk which vary to some extent with the butterfat content.

**Seasonal production.**—Quoted prices of milk vary from month to month and these variations affect the average returns for the year. It is obvious that a farm that has relatively high sales in the months when prices are high will have higher average returns for the year than a farm with heaviest sales in low price months.

TABLE 1.—Milk Returns per Hundredweight at Farm and Market  
Selected group of farms in northern Ohio, 1936

Producer Number	Range of butterfat	A.v. returns at farm, actual test	A.v. returns at farm adjusted to 3.5% butterfat	Hauling	A.v. returns at market, 3.5% butterfat
	<i>Pct.</i>	<i>Dol. per cwt.</i>	<i>Dol. per cwt.</i>	<i>Dol. per cwt.</i>	<i>Dol. per cwt.</i>
1.....	3.4-4.1	2.09	2.04	0.25	2.29
2.....	3.3-3.9	1.92	1.87	.20	2.07
3.....	3.1-3.7	1.80	1.86	.20	2.06
4.....	4.9-5.7	2.55	1.86	.20	2.06
5.....	3.8-4.8	2.11	1.83	.25	2.08
6.....	4.2-5.1	2.22	1.83	.20	2.03
7.....	3.1-3.9	1.75	1.81	.26	2.07
8.....	3.0-3.6	1.75	1.81	.20	2.01
9.....	3.2-3.7	1.79	1.85	.20	2.05
10.....	3.6-4.4	1.97	1.81	.20	2.01
11.....	3.7-4.7	2.01	1.78	.25	2.03
12.....	3.1-3.7	1.73	1.79	.25	2.04
13.....	3.4-3.9	1.84	1.78	.25	2.03
14.....	3.2-3.7	1.77	1.77	.25	2.02
15.....	3.1-3.7	1.70	1.77	.25	2.02
16.....	3.1-3.8	1.70	1.74	.25	1.94
17.....	3.3-3.7	1.70	1.71	.25	1.96
18.....	5.1-5.5	2.35	1.69	.25	1.94
19.....	4.7-5.85	2.13	1.57	.29	1.97
20.....	4.15-4.55	1.90	1.56	.27	1.83
21.....	3.55-3.95	1.66	1.56	.18	1.74
22.....	3.45-3.65	1.80	1.79	.20	1.99
23.....	3.05-3.5	1.71	1.83	.26	2.09
24.....	3.4-3.95	1.78	1.75	.23	1.98
25.....	3.1-3.45	1.63	1.69	.24	1.93
26.....	4.45-5.25	2.17	1.68	.24	1.92
27.....	4.4-5.75	2.22	1.67	.27	1.94
28.....	3.2-4.2	1.94	1.86	.25	2.11
29.....	4.25-5.45	3.02	2.53	.25	2.78
30.....	4.0-5.1	2.22	1.80	.20	2.00
31.....	4.8-5.8	2.48	1.84	.27	2.11
32.....	4.8-5.75	2.30	1.84	.25	2.09
33.....	3.2-3.6	1.57	1.65	.25	1.90
34.....	4.5-5.95	2.33	1.66	.28	1.94
35.....	3.4-3.65	1.62	1.63	.10	1.73
36.....	3.75-4.7	2.02	1.72	.25	1.97
37.....	3.4-4.0	1.75	1.73	.25	1.98
38.....	3.5-4.15	1.91	1.76	.25	2.01
39.....	4.25-5.45	2.16	1.76	.25	2.01
40.....	4.35-5.4	2.15	1.68	.22	1.90
41.....	3.75-4.35	1.85	1.63	.22	1.85
42.....	3.75-4.2	1.87	1.70	.21	1.91
43.....	4.3-4.8	2.06	1.74	.19	1.93
44.....	3.5-4.5	1.80	1.64	.29	1.93
45.....	3.2-3.9	1.70	1.67	.25	1.92
46.....	3.4-4.05	1.60	1.57	.20	1.77
47.....	4.2-5.5	1.81	1.35	.20	1.55
48.....	5.2-5.9	2.31	1.52	.15	1.67
49.....	3.95-7.5	1.94	1.53	.15	1.68
50.....	3.65-4.05	1.66	1.56	.15	1.71
51.....	3.0-3.5	1.71	1.76	.25	2.01
52.....	4.5-5.8	2.44	1.81	.25	2.06
53.....	3.5-5.2	2.07	1.77	.25	2.02
54.....	5.0-5.6	2.58	1.90	.20	2.10
55.....	3.3-3.7	1.50	1.51	.18	1.69
56.....	2.9-3.6	1.07	1.17	.18	1.35

**Marketing plans.**—From some of the farms in this group the milk is sold on the base and surplus plan and from others, on a pool or flat price. In the base and surplus plan each farm is allotted a certain amount of sales for each month, designated as base or quota, for which a higher price is paid. The farm with a high base and relatively even sales from month to month has higher returns than one of low base and irregular sales.

**Special market.**—The larger markets have special milk classifications selling at prices above those for standard milk. Farm No. 29 in this sample, which has the highest average returns, sells special Guernsey milk which commands a premium price.

**Transportation costs.**—Average farm returns are affected by the costs of transportation. In this sample the range was from 10 cents to 29 cents per hundredweight. It is significant, however, that the quoted price is generally highest at the market to which the transportation cost is the greatest. The lowest transportation cost, 10 cents per hundred in this sample, applied to delivery at a country plant where the quoted price was lower than at dealers' city plants.

**Financial responsibility of buyers.**—Average returns per hundred pounds must of necessity be calculated upon the money actually received for milk delivered. In two of the farms included in this study, Nos. 55 and 56, the buyer failed to pay for all milk delivered. Farm 55 lost 1 month's, and Farm 56, 2 months' deliveries.

Space will not permit a detailed discussion here of the manner in which these variables have affected the returns on each individual farm of the fifty-six. The range of returns at actual test from \$1.07 per hundredweight for farm No. 56 to \$3.02 for farm No. 29 is obviously much wider than that of quoted prices.

For the purpose of comparing returns after the variables of butterfat and hauling have been eliminated, returns have been adjusted to the value of 3.5 per cent milk at the farm. This leaves in the derived returns the influence of the variables: market outlets, seasonal production, and marketing plans. The range, exclusive of the farm selling special milk, is \$1.17 to \$2.04.

In order to compare returns based on delivered prices, the column giving returns at the market for 3.5 per cent milk was added. These figures are of value in comparing returns from dealers within the same market and in different markets.

# INDEX NUMBERS OF PRODUCTION, PRICES, AND INCOME

J. I. FALCONER

For the first 4 months of 1938 the prices of Ohio farm products were 16 per cent below those of the corresponding months in 1937; the cash income from the sales of these products was 18 per cent less. Farm prices had fallen to the level prevailing in January of 1935. The major items of farm expense, however, have shown little decrease.

## Trend of Ohio Prices and Wages, 1910-1914=100

	Wholesale prices, all commodities U. S.	Weekly earnings N. Y. State factory workers	Prices paid by farmers	Farm products prices U. S.	Ohio farm wages	Ohio farm real estate	Ohio farm products prices	Ohio cash income from sales
1913 .....	102	.....	101	101	104	100	105	101
1914 .....	99	100	100	101	102	102	105	108
1915 .....	102	101	105	98	103	107	106	111
1916 .....	125	114	124	118	113	113	121	121
1917 .....	172	129	149	175	140	119	182	199
1918 .....	192	160	176	202	175	131	203	240
1919 .....	202	185	202	213	204	135	218	266
1920 .....	225	222	201	211	236	159	212	226
1921 .....	142	203	152	125	164	134	132	130
1922 .....	141	197	149	132	145	124	127	130
1923 .....	147	214	152	142	166	122	134	144
1924 .....	143	218	152	143	165	118	133	146
1925 .....	151	223	157	156	165	110	159	174
1926 .....	146	229	155	145	170	105	155	177
1927 .....	139	231	153	139	173	99	147	165
1928 .....	141	232	155	149	169	96	154	156
1929 .....	139	236	153	146	169	94	151	165
1930 .....	126	226	145	126	154	90	128	137
1931 .....	107	207	124	87	120	82	89	100
1932 .....	95	178	107	65	92	70	63	73
1933 .....	96	171	109	70	74	59	69	85
1934 .....	110	182	123	90	77	63	85	98
1935 .....	117	191	125	108	87	66	110	127
1936 .....	118	199	124	114	100	71	118	147
1937 .....	126	215	131	121	118	75	128	161
1936								
July .....	118	198	123	115	105	.....	121	189
August .....	119	202	126	124	.....	.....	131	183
September ..	119	198	127	124	.....	.....	127	169
October .....	119	202	127	121	108	.....	124	164
November ..	120	201	127	120	.....	.....	123	158
December ..	123	211	128	126	.....	.....	127	160
1937								
January .....	125	209	130	131	104	.....	128	151
February .....	126	211	132	127	.....	.....	127	141
March .....	128	218	132	128	.....	75	129	157
April .....	128	219	134	130	118	.....	134	170
May .....	127	219	134	128	.....	.....	135	164
June .....	127	220	134	124	.....	.....	134	162
July .....	128	218	133	125	123	.....	138	191
August .....	128	220	132	123	.....	.....	135	171
September ..	128	215	130	118	.....	.....	129	164
October .....	125	214	128	112	127	.....	123	156
November ..	122	205	127	107	.....	.....	116	156
December ..	119	207	126	104	.....	.....	114	142
1938								
January .....	118	201	126	102	115	.....	109	135
February .....	116	204	126	97	.....	.....	105	121
March .....	116	205	125	96	.....	74	106	130
April .....	115	.....	125	94	116	.....	104	126
May .....	.....	.....	.....	.....	.....	.....	.....	.....





# The Bimonthly Bulletin

Vol. XXIII

September-October, 1938

No. 194

## Ohio Agricultural Experiment Station

WOOSTER, OHIO, U. S. A.



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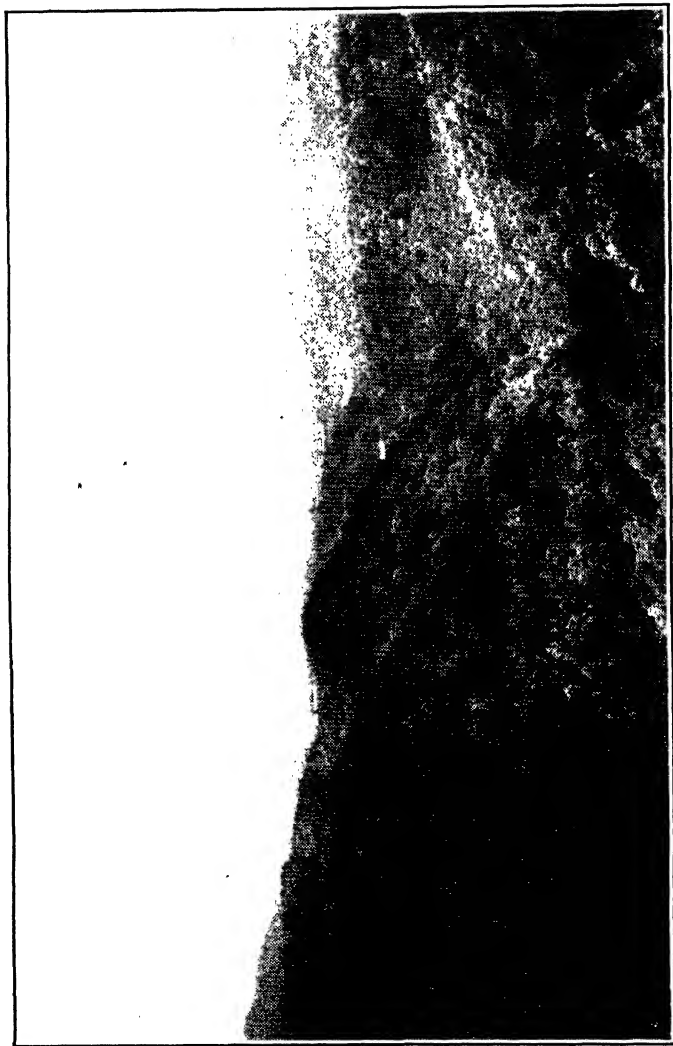
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### Free Bulletin

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*Edmund Secrest*  
Director



Shawnee Forest, Ohio River in left background

# FEEDING VALUE OF HAY CROP SILAGE

C. F. MONROE, C. C. HAYDEN, A. E. PERKINS, W. E. KRAUSS,  
G. E. KNOOP, AND R. G. WASHBURN

If hay crops are to be preserved in the silo it is important to know the feeding value of the resulting silage. It is also necessary to know whether such silage will partially or entirely replace the usual sun-cured hay in the dairy ration. The merit of ensiling these crops depends upon the value of the resulting feed and the efficiency of the process in preserving the feed nutrients.

It is well known that even under the most favorable weather conditions there is some loss in curing hay. When curing conditions are adverse the losses in nutrients are greatly increased, and sometimes the entire crop is lost. This damage involves not only an actual loss of plant material, such as leaves, but also a decreased feeding value in the portion harvested as a result of a diminished protein, mineral, and carotene content. The chief argument, therefore, for ensiling hay crops is the avoidance of sun-curing with its attendant hazards and delays.

There are four general methods of ensiling hay crops:

1. In combination with other crops which furnish carbohydrate materials for the proper fermentation
2. With the addition of a small amount of dilute mineral acids to prevent undesirable fermentation
3. With molasses for proper fermentation
4. Without any additions or treatment except possibly a preliminary wilting in the field.

All four methods have been used at this Station. The crops ensiled in quantities which have warranted feeding trials have been put up either as combination silages or with mineral acids.

## COMBINATION SILAGES

### SOYBEAN-CORN SILAGE

One form of combination silage that has found common use is made up of corn and soybeans, two crops generally ready for ensiling about the same time. This mixture has been ensiled three different times and used in feeding trials. Different proportions were used each time.

The first of these trials was reported in 1926. The mixture used contained, on the dry basis, approximately one part of soybeans to one and one-half parts of corn. The soybean-corn silage mixture was compared with soybean hay and corn silage in a double reversal feeding trial. The amounts of roughage fed in the two rations were adjusted so that the dry matter intake from roughage was the same on the two rations, or, stated another way, equivalent amounts of soybeans were fed as hay and as silage. The results in milk production and live weights of the cows indicated that there was practically no difference between the two rations. The very small difference of 1 per cent in production favoring the soybean-corn silage ration was not considered significant.

The second trial with soybean-corn silage was conducted during the winter of 1932-1933. This mixture as ensiled contained, on the dry basis, approximately two parts of soybeans to one of corn. The silage mixture was fed continuously as the sole roughage to a group of five cows from November 13 to February 22, or until the supply of silage was exhausted. This gave a feeding period of 101 days. The cows ate the silage well. Two Holsteins ate an average of 57 pounds a day, and three Jerseys, a little under 50 pounds. The average daily consumption for the group was 4.66 pounds per 100 pounds of live weight. In addition, the cows ate some straw which was used for bedding. This group maintained a normal production for the entire period when the soybean-corn silage was fed as the only roughage, without dry hay. The average monthly production for the period was 872 pounds of milk and 41.1 pounds of butterfat and there was an average live weight gain of 18 pounds. This was a little better than these cows had done in a comparable period during the preceding lactation when a normal ration containing hay had been fed.

In the fall of 1936 a mixture of soybeans and corn was ensiled for the third time. Equal weights of the two crops were used, and as the dry matter of the two was approximately equal when ensiled, the silage contained about equal quantities of dry matter from both. However, the soybean crop as ensiled was very weedy; in fact by actual weights of sorted samples the crop was approximately 50 per cent weeds, mostly redroot and lambsquarters. This silage, composed of equal parts of weedy soybeans and corn, was fed to a group of cows as the only roughage in comparison with a standard roughage ration composed of alfalfa hay and corn silage. Eighteen cows, divided into two groups, were used in the test, and the groups were alternated in 60-day periods. The grain from the same mixture was fed to both groups throughout the test. The results of this trial are shown in Table 1.

TABLE 1.—Average Production and Consumption per Cow per Month on Alfalfa Hay and Corn Silage Compared with Soybean-corn Silage

Ration	Milk	Fat	Fat	Four per cent milk	Live weight gain	Grain	Hay	Corn silage	Hay silage	Dry matter intake	Milk per pound of dry matter intake
	<i>Lb.</i>	<i>Pct.</i>	<i>Lb.</i>	<i>Lb.</i>	<i>Lb.</i>	<i>Lb.</i>	<i>Lb.</i>	<i>Lb.</i>	<i>Lb.</i>	<i>Lb.</i>	<i>Lb.</i>
Alfalfa hay and corn silage.....	920.1	4.25	39.1	954.1	11	264	349	1043	.....	872	1.094
Soybean-corn silage .....	842.4	4.36	36.7	887.3	-5.5	257	.....	.....	1817	821	1.080
Difference .....	77.7	-0.11	2.4	66.8	16.5	7	.....	.....	.....	51	0.014

Milk and butterfat productions were not as high on the all-silage ration as on the standard ration, probably because of the lower dry matter intake on the all-silage ration. Although the cows were given all the soybean-weed-corn silage they would eat, their consumption of dry matter in this feed was 51 pounds, 5.8 per cent less for each cow per month than on the standard ration. It is probable that the high content of weeds in this silage lowered the palatability. When the two rations are compared on the basis of production per pound of dry matter intake there is very little difference between them.

These three attempts at feeding a mixed silage of soybeans and corn have in general been quite satisfactory. From the results it would appear that the soybean crop has been fed out as well in a silage mixture as though it had been made into hay. Some weedy crops may better be utilized as silage than as hay.

#### ALFALFA-CORN SILAGE

A combination silage tried in the fall of 1937 consisted of alfalfa and corn. The silo was filled October 2 with nearly ripe corn and a late cutting of alfalfa containing a large amount of bluegrass and other grasses. The alfalfa and corn were mixed during the filling at the ratio of two parts of alfalfa to one of corn, on a dry basis. The resulting silage proved to be highly palatable.

Another combination silage has been made from first-cutting red clover and wheat cut in the dough stage. These crops were put into the silo in the proportion of four parts of clover to one of wheat, on the dry basis. A fairly good quality of silage, palatable to cows, resulted from this mixture. Since this was fed in the summer to cows on pasture, no accurate feeding comparison was possible.

#### ACID SILAGE

A method recently advocated for ensiling hay crops is that of treating the material with a dilute solution of mineral acid as it goes into the silo.<sup>1</sup> The acids are added in amounts sufficient to give the ensiled material a pH of 3.5 to 4.0. With such a degree of acidity, changes in chemical composition of the ensiled material are kept at a minimum.

In 1934 a crop of second-cutting alfalfa containing a large amount of clover was ensiled by the acid process. Because of a poor system of applying the acid mixture, an insufficient amount was added. The pH of the silage averaged around 4.35, instead of between 3.5 and 4.0, as desired. The silage was of good quality, however, (carotene preservation not included) and the animals ate it fairly well.

Four groups of four cows each were used in a feeding trial. Groups A and B were fed the acid silage and chopped alfalfa hay, respectively, as their sole roughage for the entire winter feeding period. The grain fed was the same for both groups, a 14 per cent protein mixture. The cows receiving the acid silage were each fed 4 ounces of finely ground limestone daily; those receiving the hay, 2 ounces daily.

Groups C and D were fed the acid silage and alfalfa hay in alternate periods. The acid silage was fed to the cows' capacity to consume and the alfalfa hay, in amounts to equalize the dry matter intake of acid silage. In all other respects both groups were fed and treated alike. All cows received corn silage at the rate of 2 pounds per hundred of live weight daily, a 14 per cent grain mixture, and limestone.

The results of this reversal trial are shown in Table 2.

The cows on the acid silage ration produced more milk and butterfat than those on the hay ration, but the dry matter intake also was greater on the acid silage ration. This larger intake was the result of limiting the hay consumption in an attempt to equalize the dry matter intake between hay and acid silage. This should not be interpreted to mean that the cows would naturally have eaten more acid silage than dried hay.

<sup>1</sup>This system is known as the A. I. V. process. The letters are the initials of the originator, A. I. Virtanen. The acids used were hydrochloric and sulfuric. Dilute solutions (2-normal) of these were mixed in the proportion of 4 parts of hydrochloric to one of sulfuric by volume.

The results with the groups fed continuously on either the acid silage or the chopped hay indicated that there was no marked difference between the rations. The chief object in conducting this part of the work was to bring out the effect, if any, of the long-continued heavy feeding of the acid silage; the chopped hay feeding was used as a basis for comparison. The groups were fed all they would eat of these rations for a period of 4 months. During these 4 months the average consumption of the acid silage was 1597 pounds per cow per month. The production of the cows eating the acid silage was considered approximately normal as based on their production in the preceding lactation periods.

Blood and urine analyses of these cows were made at intervals. The blood analyses showed little or no difference between the groups. In the analyses of the urine certain differences were noted, indicating that the acid silage produced an effect on this excretion. The changes were not considered sufficient to be detrimental to the health of the animals.

**TABLE 2.—Milk Production and Feed Consumption by Reversal Groups (31-day basis)**

	Milk	Fat	Fat-corrected milk (4 per cent)	Grain	Corn silage	Alfalfa hay	Acid silage	Dry matter intake	Fat-corrected milk per pound of dry matter intake
	<i>Lb.</i>	<i>Lb.</i>	<i>Lb.</i>	<i>Lb.</i>	<i>Lb.</i>	<i>Lb.</i>	<i>Lb.</i>	<i>Lb.</i>	<i>Lb.</i>
Silage ration ..	915.3	35.0	891.4	272	708	.....	1349	865	1.031
Hay ration ....	879.4	33.2	850.2	273	742	338	.....	806	1.054
Difference ...	35.9	1.8	41.2	— 1	— 34	.....	.....	59	—0.023

The general plan for feeding the acid silage was practically the same during the second trial. First-cutting alfalfa containing some clover and timothy was cut into approximately inch lengths by a silage cutter and run into a wooden silo. During the filling process the acid mixture was sprayed onto the cut material in the silo. Twenty gallons of the dilute acid of double-normal strength were used on each ton of green material. Previous laboratory trials with small quantities of material had shown this to be the amount of acid required to bring the material to pH 3.5. After the filling had been completed the silo was immediately topped by putting in about a ton of green alfalfa without acid, then a covering of tar paper, and finally dry wood shavings to a depth of 8 inches. The filling was completed on June 13 (1935).

When the silo was opened the latter part of October the same year, the spoiled material on the top was limited to 1000 pounds, mostly nonacid alfalfa. The remaining silage proved to be of excellent quality, contained practically no spoilage, and was palatable to the cows. The pH of the silage averaged 3.67.

The original plans in this work called for feeding one-half of the field as acid silage and the other half as hay. However, because of heavy rains the hay crop was lost. This experience was general in Ohio during June of 1935. As a result of losing the hay crop it became necessary to substitute first-cutting shipped-in alfalfa hay in the check ration.

Four cows were fed the acid silage as the only roughage straight through the winter feeding period. Another group of four cows was similarly treated, except that the cows received first-cutting alfalfa hay in place of silage. Two groups of seven cows each received the acid silage and alfalfa hay in alternate periods of 70 days. Both groups received corn silage and the same grain ration, which contained about 14 per cent of total protein. Finely ground limestone was given the cows as in the preceding trial. A small amount of potassium iodide was also fed to prevent any iodine deficiency.

The results of this second trial with acid silage are shown in Table 3.

TABLE 3.—Milk and Butterfat Production per Cow per Month with Feed Consumption

	Milk	Fat	Fat-corrected milk	Grain	Corn silage	Alfalfa hay	Acid silage	Dry matter intake	Fat-corrected milk per pound of dry matter intake
	<i>Lb.</i>	<i>Lb.</i>	<i>Lb.</i>	<i>Lb.</i>	<i>Lb.</i>	<i>Lb.</i>	<i>Lb.</i>	<i>Lb.</i>	<i>Lb.</i>
Acid silage . . .	868.8	37.2	905.8	307	574	.....	1231	860	1.053
Alfalfa hay . . .	801.0	34.5	838.1	297	581	308	.....	758	1.105
Difference . . .	67.8	2.7	67.7	10	-7	.....	.....	102	-0.052

Both milk and butterfat productions were higher on the acid silage ration than on the alfalfa hay ration. This increase in production is probably a result of the feed intake. The cows on the acid silage ate more total pounds of dry matter than those on the alfalfa ration; the greatest difference occurred in roughage consumption. Although this speaks well for the palatability of the acid silage, it does not mean that this silage was so much more palatable than hay, but rather that a sufficient amount of hay was not given the cows to balance up the acid silage, which was limited only by the cows' ability to eat it.

The group fed the acid silage continuously throughout the winter period behaved much as the cows so fed in the preceding trial. These cows suffered no ill effects from this type of feeding. Although there were definite changes in the urine reactions, these changes were not sufficiently extensive to be regarded as indicative of a pathological condition. In trials with other cows it was found that alfalfa hay fed with the acid silage was more effective in restoring urine reactions toward normal than was limestone. It is felt that the feeding of some other roughage, such as hay or corn silage, along with the acid silage is desirable. Such feeding gives a greater variety and also helps to prevent the changes caused by the acid silage.

### MOLASSES SILAGE

Although molasses was used as the preserving agent several different times when hay crops were ensiled, no extensive feeding trials were conducted with silage preserved in this manner. The molasses silage has generally been made early in the season from the first cuttings and then fed out in midsummer during the period of pasture shortage as a pasture supplement.

In June of 1936, a small silo was filled with first-cutting alfalfa molasses silage. The alfalfa crop was not pure alfalfa but contained some red clover, timothy, and a small amount of bluegrass and weeds. In making this silage, molasses was added at the rate of 40 pounds per ton, or at the rate of 2 per cent on the fresh weight basis.

A similar silo was filled with like material without the addition of molasses. It was used as a check or control for the other.

When these two silos were opened there was little apparent difference in the quality of the silage from them. Hence, in the feeding work the molasses-treated material and the untreated were combined and spoken of as legume silage.

This legume silage was fed as a midsummer supplement to cows on pasture. For this trial the cows were divided into two similar groups which were treated alike except in the rate of grain feeding. The plans called for feeding group A, 1 pound of grain for each 8 pounds of milk produced and group B, 1 pound for each 4 pounds of milk produced, on a daily basis. The production was calculated to 4 per cent fat-corrected milk. In the actual feeding the grain was fed to both groups a little more heavily than indicated by these ratios.

The results of this feeding are shown in Table 4.

**TABLE 4.—Legume Molasses Silage as a Summer Supplement to Pasture  
(Two Different Levels of Grain Feeding Used)**

Feeds Consumed, Milk Produced, and Live Weight Change—40-day Period

Group	Legume molasses silage fed	Grain fed	Four per cent milk produced	Net live weight change
	<i>Lb.</i>	<i>Lb.</i>	<i>Lb.</i>	<i>Lb.</i>
A, 7 cows (light grain feeding) .....	11,095	1,086.3	7,230.3	—50
B, 7 cows (heavy grain feeding) .....	11,721	1,882.2	7,233.5	—56
Difference.....	626	796.0	49.5	6

The heavier grain feeding of group B resulted in practically no increase in production over group A. The 796 pounds of additional grain brought an increase of only 3.2 pounds of milk.

In another trial the difference made in the feeding of two similar groups of cows was in the feeding of the legume silage. One group of cows was given all this feed they would eat and the other group, none. The same grain mixture was fed to both groups in like amounts. The results are shown in Table 5 for the three low producing cows in each group and in Figure 1 for the three high producing cows in each group.

The cows receiving the silage kept in better condition and produced better than those without the silage. This difference in production is striking for the heavier producing cows. Those not receiving the silage showed a continuous decline; whereas those given all the silage they would eat more than held their own in production. The three cows fed silage lost 8 pounds in live weight and the three without silage lost 230 pounds, over a 40-day period.

During the summer of 1937 first-cutting alfalfa was again ensiled with molasses. The resulting silage, which was of fairly good quality, was used as a supplement for cows on pasture during the summer. As did the previous summer's feeding, this work showed that the alfalfa molasses silage may be of great value in preventing the summer decline in milk production due to a shortage of pasture.

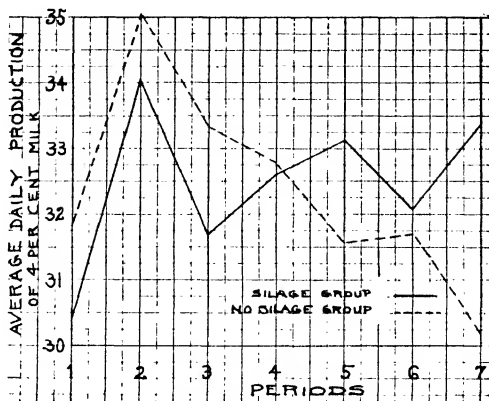


Fig. 1.—Average daily production of 4 per cent milk by cows on pasture, with and without silage  
(Three heavier producing cows in each group)

### PALATABILITY OF HAY CROP SILAGES

The combination silages have proved the most palatable at this Station. The acid silage has been palatable up to a certain amount, but it has not been possible to feed large amounts of this silage when it was used as the only roughage. The experience with molasses silage has been more limited.<sup>2</sup> In free-choice feeding of this silage to a group of dry cows the consumption was 36.5 pounds daily per cow. These cows had access to pasture and the conclusion under these conditions was that this silage was fairly palatable.

TABLE 5.—Results of Feeding Cows on Pasture with and without Legume Silage

Feeds Consumed, Milk Produced, and Live Weight Change on Silage Supplement

Group	Legume silage fed	Grain fed	Four per cent milk produced	Live weight change
A, 3 cows (silage).....	Lb. 2879	Lb. 541.3	Lb. 1962.2	Lb. 161
B, 3 cows (no silage) .....	none	463.4	1529.6	—1
Difference .....	.....	—77.9	—432.6	160

<sup>2</sup>Some mixed pasture herbage, mostly bluegrass, ensiled with 2 per cent molasses the latter part of May this year (1938) has proved to be quite palatable thus far (August 1, 1938).

Feeding some of the hay crop silages free-choice along with corn silage has shown that the cows prefer the corn silage, as they ate two to three times as much of the corn silage as they did of the hay crop silages.

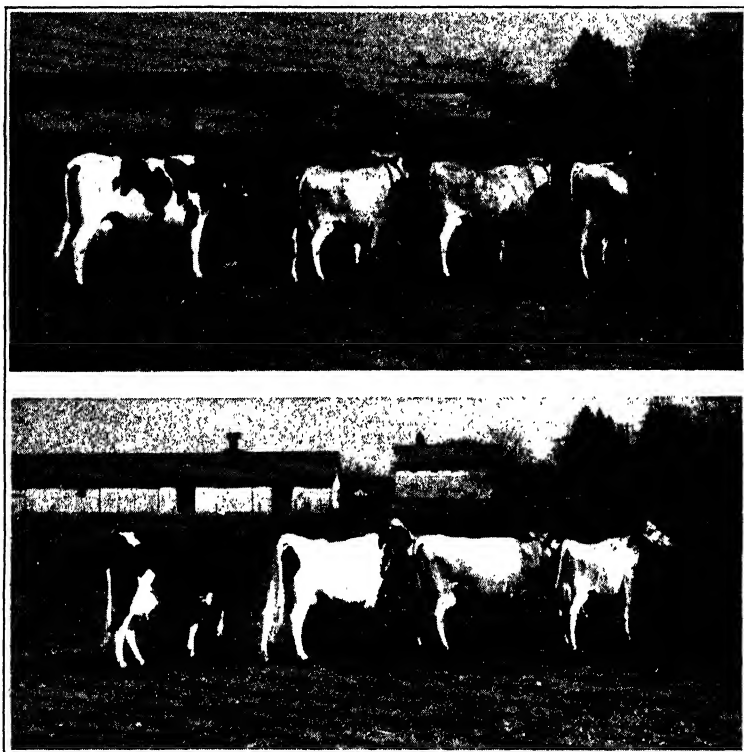


Fig. 2.—Cows on continuous-feeding trials. The upper group received acid silage; and the lower group, chopped alfalfa hay as the only roughage for 127 days of the winter feeding period.

Both groups remained in good condition and produced normally.

### THE PLACE OF HAY CROP SILAGE IN THE RATION

The chemical reactions that take place in the silo do not radically change the composition of the feed preserved in the silo. When hay crops are stored in the silo by one of the various methods, the material remains essentially hay, differing of course from the latter in moisture content, also in flavor and aroma. The ensiling process will not convert a grass or legume crop into a feed similar in composition to corn silage. Therefore, in feeding silage it is well to keep in mind the character of the material used for making the feed. Hay crop silage should be regarded as hay in a slightly different form, with due allowance for the moisture content.

In the experiments discussed in this article hay crop silages and the hay crops contained in the combination silages were compared with hay on the dry matter basis. The general indications from this work were that the cows did equally well whether the hay crop was fed in the ordinary manner as dry hay or in the form of silage. A normal production was maintained when the cows were fed for the usual winter feeding period with hay silage as the sole roughage. Therefore, when occasion demands, the hay crop may be stored and fed as silage. Such a procedure may be used when unfavorable hay-curing weather occurs, as an emergency measure, or it may become a standard practice on some farms.

When hay crops are stored in the silo, corn silage will be reduced in amount or entirely eliminated. The problem is then one of feeding the herd without corn silage, and this has been done successfully, both experimentally and practically.

When large amounts of legume roughage are used, either in the form of hay or silage, or both, the protein supply will be ample for a daily production of 30 to 40 pounds of 4 per cent milk. The energy supplied by such roughage, however, will not be sufficient for the production of this amount of milk. Compensation is made for this deficiency by the type of grain mixture used. The grain mixture should be low in protein and high in total energy. A larger proportion of the carbonaceous or farm-grown grains, such as corn, oats, and barley, should be used under a system of legume roughage feeding. The legume silages used in the experiments described in this article have varied between 11.5 per cent and 15.8 per cent total protein; the lower figure is for those combination silages containing the nonleguminous roughages. Straight corn silage, on the dry basis, usually analyzed between 7 and 8 per cent total protein.



Fig. 3.—Feeding troughs used for determining the relative palatability of the different silages. Cover raised on the trough at the left

Corn silage proved more palatable than any of the hay silages.

### THE FUTURE OF HAY CROP SILAGE

Since hay crop silages make satisfactory substitutes for hay in the dairy ration, the farmer is not compelled to depend entirely on feeding hay and to incur the losses connected with the curing of this roughage. In unfavorable seasons and at other times, part of the hay crop may be converted into silage. The hay crop may be cut with less delay caused by unfavorable drying conditions when it is to be used as silage. Hence, overripeness and the losses incurred from it may be avoided. The time element is of special importance when the acreage in hay is large.

One of the chief difficulties in making hay crop silage has been the manual labor of handling the heavy material. With the development of suitable machinery, however, this difficulty is being overcome. It is entirely reasonable to suppose that improvements will be made in the process of ensiling hay crops which will not only increase the feeding value and palatability of such silage but will also lead to a greater certainty in obtaining a satisfactory product.

### SUMMARY

Three feeding trials were conducted with a combination silage of soybeans and corn in comparison with the usual hay and corn silage.

Two trials were conducted with acid silage made from alfalfa and clover mixtures in comparison with ordinary hay rations.

In some trials cows were fed continuously throughout the winter feeding period on the soybean-corn silage or the acid silage as the only roughage.

The results indicate that hay silages may be satisfactorily fed to replace sun-cured hay and that such feeding may be continued for the winter feeding period without apparent ill effect to the cows.

A summer's feeding trial of alfalfa molasses silage to cows on pasture showed that under certain conditions such silage may be of more value than grain in maintaining production.

## THE VALUE OF MILK IN THE DIET

W. E. KRAUSS

Milk is the most common food of the human race; everyone is born a natural milk drinker. Although this is as intended by Nature, it was left for the knowledge of man to discover that when the mother's milk supply had been depleted or the natural time for weaning had been reached, milk from other species, like the cow, was entirely adaptable to human consumption and even necessary for proper development of the growing child and for the well-being of young folks and grown-ups.

The value of milk is well demonstrated by a survey of the dietary habits of the different native races inhabiting the world. Fine physique, good health, and virility are usually seen in races where milk has an important place in the diet, as, for example, among the Arabs and other races inhabiting Southwestern Asia and Southeastern Europe. The contrast in health, strength, and stamina between the hill tribes of India, who partake largely of milk, and those dwelling in the plains, where the diet is more exclusively vegetarian and consists largely of cereals, is proverbial.

For a long time the value of milk as a food was taken for granted. Consequently, emphasis was placed on improving the sanitary conditions surrounding the various phases of milk production. Twenty-five or thirty years ago people took their own containers to the corner grocery store and had them filled with the amount of milk estimated to meet the family's needs for the day. It may be remembered how the storekeeper would dip the milk out of an open, smelly can and that occasionally, particularly in warm weather, he would take off a cent or two on the price of a quart because the milk was a little bit "off". Today it is possible to place on the doorstep a quart of milk that has hardly been exposed to the air, let alone human hands. Such great advances have been made in the sanitary aspects of milk production that the consumer is practically assured of the safety of the milk he drinks.

As the science of nutrition was developed and new hitherto unknown factors that contribute to the value of foods were discovered, the value of milk as a food was reinvestigated. As a result of the newer knowledge of nutrition, many of the things formerly taken for granted have been shown to have sound scientific basis, and other favorable attributes not previously known have been brought to light. At the same time one or two weaknesses or deficiencies were encountered that made it possible better to understand the limitations of milk, as well as its virtues. Knowledge such as this regarding any food product results in more intelligent use of it.

Although many of the virtues of milk as a food are generally known, the idea still persists that this product is intended only for infants and very young children. There is also a false economic impression that milk is an expensive food. It would probably be well, therefore, to take milk apart, so to speak, and find what it contains that makes it entitled to the classification of "the most nearly perfect food".

Milk contains two substances, milk sugar and milk fat, that yield essentially energy when consumed. The human body needs energy to carry on its life processes, and the amount of energy needed depends upon the degree of activity. The amount of energy furnished by foods is expressed in heat units or calories. Milk is not a high caloric food, yielding about 325 calories per pint or per pound. Compare this with the 2400 calories per day recommended by the League of Nations as the minimum number of calories required by the average person doing no manual labor, and the conception that milk is a fattening food is at once shown to be a fallacy. This false impression has probably arisen because the liberal use of milk does so often result in weight gains in undernourished or unhealthy individuals, or because an increased amount of milk has been added to the diet while the intake of other foods has been maintained at an already adequate or excessive energy level.

Milk contains three proteins—casein, albumin, and globulin—which have been shown to be exceptionally efficient as yielders of the building stones needed for making proteins of the body.

A mineral, in the popular conception, is something that is dug out of the earth. Yet the human body contains many minerals and therefore requires these substances in its food. One of the minerals needed for blood formation is iron. Although milk contains iron in readily available form, the amount present is too small to allow one to continue indefinitely on a diet of milk alone. It is for this reason, probably, that physicians recommend the addition of iron-containing foods like egg yolk and strained vegetables to the diet of infants.

There are two minerals that are needed in particularly large quantities by the body because they are the principal constituents of bones and teeth. These are calcium, commonly known as lime, and phosphorus. Milk is the best natural food source of calcium and it is also an excellent source of phosphorus. It can readily be shown that it is almost impossible to meet the calcium requirements of the body without including in the diet rather liberal quantities of milk or cheese. A rapidly growing child requires about 1 gram of calcium daily; an adult needs about half that amount. One quart of milk contains about 1 gram of calcium. This is the nutritional basis for the slogan "a quart of milk a day for children and a pint a day for adults". This does not mean that a quart or a pint of milk must be consumed in liquid form daily. Allowance can be made for liquid milk used in cooking and for concentrated milks, cheese, and ice cream, however they may be used in the home. The average per capita consumption of milk in the United States today is approximately half a pint.

Until recently it was thought that a diet was complete when it contained a sufficient amount of proteins, carbohydrates, fats, and minerals. It is now known that another group of substances, the vitamins, is necessary. The simplest classification of the vitamins at the present time lists six: A, B, C, D, E, and G. Milk contains all of them, in different concentrations to be sure, and depending to some degree upon how the cows producing the milk were fed.

Milk may be considered to be a good and rather constant source of vitamins B, C, E, and G. Except for vitamin E, these are found in the serum of milk, that is, in the part below the cream line. Above the cream line are found two very important vitamins—A and D. In the summer time when cows are on pasture, milk is very rich in vitamin A. The amount present in milk during the winter is considerably less than in the summer but even then milk may still be considered a good source of this factor. Vitamin A content and depth of yellow color in milk are correlated because the yellow pigment, carotene, is the form in which vitamin A appears in plants, and much of this pigment is transferred to milk by the cow. Most people have observed that as the winter progresses, the milk they buy seems to get whiter and whiter. This should cause neither alarm nor complaint. The milk dealer and the farmers who produced the milk have done nothing unusual to bring this condition about. It develops as a result of unavailability during the winter months of feeds that are rich in carotene. It will be of interest to know that steps are now being taken to develop systems for preserving this yellow pigment in plants that are to be fed to cows during the winter months. June milk in December is no longer only an ideal.

Vitamin D, the one concerned with proper skeletal development, is also found in the fat of milk and is more abundant in summer milk than in winter milk, but even under the best conditions milk, along with almost all other natural foods, must be considered a poor source of this factor. Recognizing this, attempts were made several years ago to increase the vitamin D content of milk by various methods. As a result, a product known as "vitamin D milk" is now available in most of the larger cities and their surrounding towns. Adequate amounts of vitamin D are necessary to allow the calcium and phosphorus of milk to be utilized to best advantage.

The question is often raised as to how pasteurization affects the food value of milk. As usually carried out, pasteurization reduces somewhat the amounts of vitamins B and C in milk. No concern whatsoever need be felt about this because these factors are so readily supplied in other foods. Carefully controlled experiments with children receiving, in addition to their usual foods, either raw or pasteurized milk, have failed to show that the consumption of pasteurized milk was in any way detrimental.

This completes our breaking down process or analysis of milk from the nutritive standpoint. We have found that it contains in readily available form all the necessary food nutrients and vitamins in such quantity that a diet of nothing but milk will sustain life for a considerable length of time. Analysis of the available information on the value of milk as a food shows that in general the equivalent of a quart of milk a day for children and a pint a day for adults is a good rule to follow. For many years at Columbia University studies have been in progress to show the value of adding more milk or the factors found in abundance in milk to an already good diet. The general well-being of the experimental rats receiving the supplemented diets has been improved and their span of life has been lengthened. Although results with small experimental animals cannot always be interpreted in terms of humans, it is safe to infer that to raise our present low per capita milk consumption level would prove to be a public health measure.

# **FREEZING INJURY TO STRAWBERRY FLOWER BUDS, FLOWERS, AND YOUNG FRUITS**

**LEON HAVIS**

The flower buds and flowers of the strawberry are often injured slightly by late spring frosts in Ohio, and more rarely the buds, as well as young fruits, are severely injured or destroyed. It is often remarked that there is considerable difference in the resistance of varieties to frost injury, but there are few data to substantiate such a statement. The growth habit of the plants, stage of development of the flower or fruit, and the flower parts most likely to be injured are only a few of the factors usually related to the relative amount of damage resulting from a frost.

The severe frost on May 12, 1938, caused considerable damage to the strawberry crop throughout most of Ohio. This frost or freeze was one of the most destructive to strawberries at the Experiment Station in at least 25 years. It is not unusual for such low temperatures to occur as late as May 12, but it is unusual for strawberries to be as far advanced as in 1938. The flower buds and young fruit were 10 to 12 days more advanced than ordinarily. The severe freezing damage to the large number of strawberry varieties at the Experiment Station offered an unusual opportunity to secure information on this subject. It seemed especially desirable to secure data on the relative resistance of some of the newer varieties. It is not meant to imply that relative spring frost resistance should be a primary consideration in the choice of a variety. Other factors, such as vigor, productiveness, resistance to insects and diseases, and desirable fruit characters, are more often of primary importance.

In regions where spring frosts occur often, it is preferable to select sites that are relatively free from frosts and, if possible, to delay removal of the mulch until the danger of injury from frost is past, rather than to depend altogether on the use of the most frost-resistant varieties. Sometimes it is possible to save a berry crop by re-covering the plants with straw from the middles when a frost is predicted after the straw has been removed. The straw should not be left over the plants too late in the spring, however, since that results in late ripening of the berries and reduction in the total yield.

## **PLANTS AND METHODS USED**

Thermographic records taken within 200 feet of the Station strawberry planting showed that the temperature reached 32° F. at about 4:00 a. m. on May 12, 1938. They indicated that it remained below this point for about 4 hours, from 4:00 a. m. to 8:00 a. m. The temperature was below 30° F. during 2 of these 4 hours, from 4:30 a. m. to 6:30 a. m. The minimum recorded at this location was 29° F., but it was probably slightly lower than that around the strawberry plants, since the records were made in a protected container at a height of about 5 feet.

The plants used in this study were set out in the early spring of 1937. The matted row system was followed in which the plants were set 1½ feet apart in rows 3½ feet wide. The straw mulch was removed on April 13, 1938. All

varieties were duplicated in the planting. In the earliest varieties the largest fruits were about the size of peas. In most cases they were just past full bloom. In the recording of the results all flower buds on a given inflorescence were included. At least 200 flower buds of each variety were examined.

## RESULTS

The embryos of the strawberry seeds are often injured by frost, and this results in poorly developed fruits. The styles also seem relatively tender to frost and may be injured before pollination has taken place. The frost which occurred May 12, 1938, was so severe that the obvious injury at that time was to the entire receptacle, or fleshy part of the fruit. In taking the records here presented (Table 1) if the receptacle was dark the flower or fruit was counted as injured. The total amount of injury was, of course, greater than recorded by this method, since the injury only to the embryos and styles or even stigmas was not included.

The earlier varieties showed the most injury from the frost. The flower buds which were most advanced were also usually injured most severely. It may be noted from the data (Table 1) that the varieties in which the receptacles were most severely injured were Catskill, Mastodon, Premier, Culver, and Fairfax. The Clermont, Blakemore, Dorsett, and Pathfinder were almost as severely damaged. Those which were blackened least by the freeze were Gem, Chesapeake, Pearl, Wayzata, and Dunlap. The Chesapeake and Pearl are relatively late varieties, and their lack of damage may be accounted for by the lack of advancement of the flower buds. The flowers and young fruits of the Gem, Wayzata, and Dunlap seem to be relatively resistant to this type of injury. This resistance could hardly be accounted for by relative length of flower stalks or by amount of foliage protection.

TABLE 1.—Spring Frost Injury to Flower Buds, Flowers, and Young Fruits of Certain Strawberry Varieties

Variety	Injury observed just after freeze (per cent)	Yield of fruit (quarts per 150 feet of row)
Aberdeen .....	50	20.6
Blakemore .....	58	15.9
Catskill .....	77	12.1
Chesapeake .....	24	16.4
Clermont .....	62	25.9
Culver .....	66	14.8
Dorsett .....	58	5.4
Dunlap (Senator Dunlap) .....	38	10.8
Fairfax .....	66	7.5
Gem .....	24	27.3
Mastodon .....	71	11.9
Pathfinder (N. J. No. 35) .....	58	21.3
Pearl .....	28	26.1
Premier .....	68	34.1
Wayzata .....	35	17.4

The yields of fruits of the various varieties (Table 1) are not closely correlated with the relative amount of injury to the receptacles of the blossoms and young fruit given in the same table. This is especially true for certain varieties. Many fruits of certain varieties failed to develop because of destruction of the embryos and styles; whereas in other varieties there was much less of this type of injury. For example, Premier showed 68 per cent destruction of

the receptacles of the flowers and young fruits and a yield of 34.1 quarts per 150 feet of matted row; whereas Dorsett showed only 58 per cent destruction of the receptacles, but the yield was only 5.4 quarts. The yield of Premier was probably between 25 and 30 per cent of that which would have been produced if there had been no frost injury, but the yield of Dorsett was only 10 to 15 per cent of the amount that it might have produced had there been no injury.

Although there was some injury to the embryos of Premier often resulting in many worthless fruits (Fig. 1), the amount of this type of injury was relatively much less than in Dorsett. These same relationships could be noted in other varieties. Clermont, Culver, Gem, Mastodon, Pathfinder, Premier, and Wayzata showed relatively little injury to the embryos. Aberdeen, Catskill, Dorsett, Dunlap, and Fairfax showed considerable damage to the embryos.

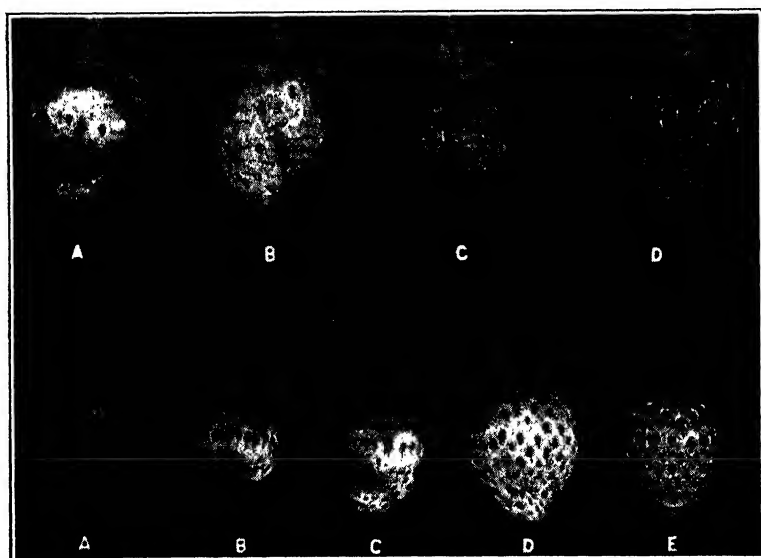


Fig. 1.—Variation in locations of frost injury to pistils of strawberry fruits resulting in distorted shapes of the receptacle or fleshy part, variety Premier. D, top row, and E, bottom row, show little or no injury.

Examination of the embryos of a large number of fruits of these varieties showed that it was not always possible, from outward appearance of the akene (commonly but incorrectly called seed) nor from the shape of the developing fruit, to determine the amount of injury to the embryos. On the whole, the fruits that contained the most destroyed embryos were the most poorly developed, but some varieties seemed to be capable of producing well-shaped marketable fruits in spite of a relatively large number of akenes with dead embryos. It was thought that perhaps the varieties in which the akenes were most prominent on the fruits would show relatively more injury to the embryos, but examination showed that there was little if any relationship to that character.

Darrow (1) has shown that there is considerable variation in number of inflorescences and flowers produced by different varieties. In comparative resistance to frost damage, however, there seemed to be little relationship to that character. For example, Darrow's data show that Premier produced an average of 2.9 inflorescences and 23.4 flowers per plant, which is very near the average numbers given for the 48 varieties listed by him. Although the writer did not examine as many varieties as did Darrow in his studies, the same general conclusions seemed to be justified with the varieties studied. Furthermore, no additional productive inflorescences were found to develop from the crown after this freeze.

### TYPES OF INJURY

The receptacle, or fleshy portion of the strawberry fruit, was the part first noted as injured. At the time that the first injuries were recorded (a few days after the frost) where any injury at all was noted the entire receptacle or torus was completely killed. The anthers of the stamens were probably the next most tender flower part. These were followed in order by the petals and then the filaments of the stamens. There were a few exceptions to this general order of hardness, since in some cases the anthers and petals were injured but the receptacle remained uninjured. The most advanced buds were usually killed first, but there were exceptions to this. In some cases fruits as large as peas were uninjured; whereas unopened flower buds near them were completely destroyed. In most instances the receptacle seemed as tender as the ovules or embryos, but there were many flowers where some of the ovaries or parts within seemed to be killed and the receptacle was uninjured. This was, of course, more obvious during the process of development of the fruits. At maturity several degrees of injury were noted and there were many fruits of distorted shapes (Fig. 1).

### CONCLUSIONS

Strawberry varieties vary considerably in their resistance to frost or freezing injury. This variation can be noted (1) in their relative resistance to injury of the receptacles of the flowers and young fruits, (2) in their relative resistance to injury of the embryos, and (3) in their characteristic of developing marketable fruits in spite of some injury. All types of injury were, as a whole, most severe in the earliest flowers of any variety. In varieties ripening at the same season there seemed to be little relationship between the amount of injury and height of inflorescence, number of leaves per plant, prominence of akenes, or number of inflorescences and flowers per plant.

As the season advanced following the frost and many berries failed to develop because of the destruction of the ovules or embryos, the resistance of Premier became more evident. Apparently, although the receptacle or fleshy part of the fruit of this variety is no more resistant to low temperatures than that of many others, the embryos of the seeds are more resistant. Furthermore, Premier berries seemed more likely than those of most varieties to develop into marketable fruits in spite of some embryo injury. Although the

1. Darrow, G. M. 1929. Inflorescence types of strawberry varieties. *Am. Jour. Bot.* 16:8:571-585.

yield of Premier at the Experiment Station, as well as in many other parts of the State, was reduced considerably by the frost, this variety should still be considered in first place as a commercial berry for most parts of Ohio. Under the conditions of this test, the Wayzata and Gem varieties seemed especially hardy to frost, but they are of the everbearing type, and the commercial value of this type of strawberry in Ohio is limited.

## OHIO WHEAT FIELD INSECT SURVEY FOR 1938

T. H. PARKS

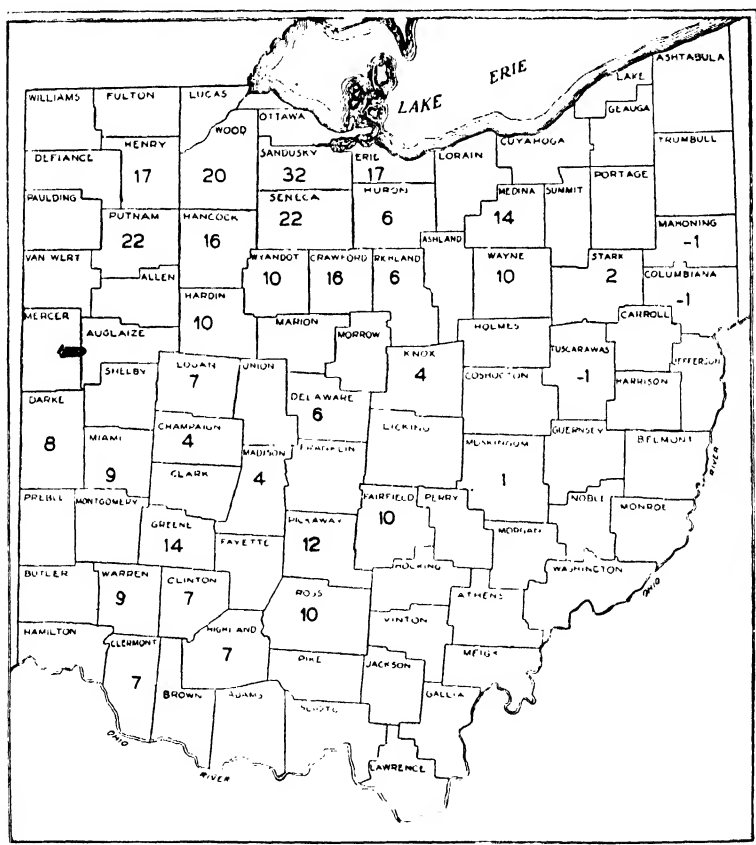
Hessian fly is now a problem in Ohio. Although insects did not take a serious toll from the 1938 wheat crop in the State, Hessian fly made a noticeable gain, especially in the northwestern section. The status of the insect was accurately determined by the Ohio entomologists, who made the annual wheat insect survey in 34 counties just previous to harvest. Hessian fly has increased since 1 year ago in 26 of the 34 counties visited. The average percentage of straws found to be infested throughout the State this year was 10.0 per cent, compared with 4.3 per cent in 1937.

The heaviest infestation this year was found in a group of northwestern Ohio counties, where the insect is approximately four times as abundant as it was 1 year ago. The most severe damage to the wheat was found in Sandusky, Seneca, Wood, and Putnam Counties. There some fields were visited which had from 30 to 65 per cent of the straws infested. One early sowed field in Wood County had 91 per cent of the straws infested. Most of the infested straws remained standing, and the kernels matured. Other stalks did not form a head because the culms were infested by the Hessian fly maggot early in their development and were killed before the head formed. Some of the infested straws lodged and were not gathered by the harvester. Very few of the fields visited were found to be free of the insect, though a group of eastern counties had only a trace of infestation. The percentage of wheat straws carrying puparia, or flaxseeds, in each county visited by the entomologist is shown in Figure 1.

A fair estimate of the probable infestation of the counties which were not surveyed may be made from the survey data of near-by counties. Although the heaviest infestation was found in the fields sowed before the fly-free dates, as usual some Hessian fly infestation was found in the fields sowed after these dates. The presence of infestation in the late sowed fields is due to the migration of spring-brood adults during May from early sowed and volunteer wheat to the late sowed fields. This makes the control of Hessian fly a community problem. Frequent rains during the spring and early summer aid this insect materially, and all parts of Ohio had an excess of moisture in May.

The insect spends the summer in the puparia, or flaxseed stage, in the stubble fields and emerges as a "mosquito-like" adult during September and early October. Emergence is heaviest about the middle of September in northern Ohio and is completed about October 1. The date of emergence as well as

the cessation of egg-laying is progressively later toward the central and southern parts of Ohio. The so-called safe-sowing dates shown in Figure 2 indicate the dates on, or after which, wheat can be sowed and be reasonably free from fall infestation. Twenty years of research work with Hessian fly in Ohio mark these dates as fairly safe guides for farmers in sowing their wheat. During the fall of 1937, many Ohio farmers who had not incurred serious loss from Hessian fly in recent years sowed their wheat a few days ahead of this date. Although no great losses occurred in the 1938 wheat crop because of this early sowing, it is apparent that such a procedure would be very risky during the fall of 1938. Throughout a period of years, maximum yields have been secured from wheat sowed on, or immediately after, these dates on soil that has been well prepared and fertilized.



Chinch bugs did no damage, but were found to be present in a few fields in the northern half of the State. Armyworms were reported only from Butler County. Wheat jointworm was very scarce; wheat midge was not reported.

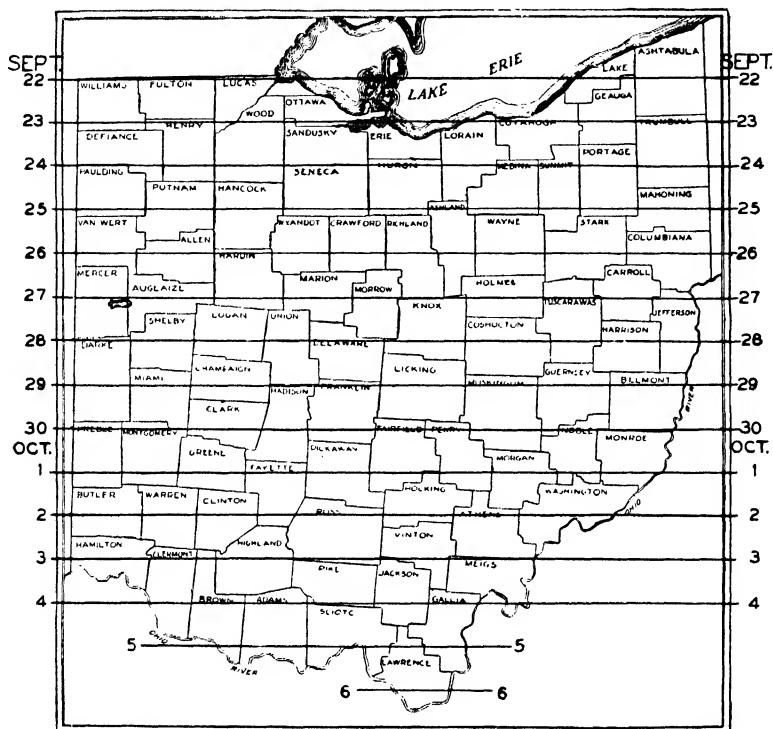


Fig. 2.—Hessian fly safe-sowing dates

In the opinion of the entomologists, general observance of the safe-sowing dates will be quite necessary this year if the 1939 wheat crop is to be protected from serious loss by Hessian fly.

## THE BLACK WHEAT-STEM SAWFLY

J. S. HOUSER

The black wheat-stem sawfly decreased sharply in abundance this season and little advance was made in the spread westward. This announcement will be welcome news to Ohio wheatgrowers who are acquainted with this new wheat pest and who have studied its advance since its presence was discovered in 1934.

An announcement of the discovery of the sawfly was made in the September-October, 1934, issue of the Bimonthly Bulletin of the Station. Each year following, a progress report on the insect has been issued in the same number of the bulletin. The present report is the most encouraging it has been possible to issue to date.

Slightly in advance of wheat harvest, 26 counties within the area of known occupancy and the periphery of the area were visited by Experiment Station entomologists, and samples of standing wheat were taken for analysis. The results of this study are shown in Figure 1. This year the insect was found for the first time in Cuyahoga, Huron, and Richland Counties and some new territory was added in Geauga and Athens Counties. In a few of the counties within the last year's area of occupancy, there was a slight increase in infestation, as for example, Geauga, Portage, Summit, Wayne, Holmes, Knox, Coshocton, Perry, and Athens, but these increases were so slight that they are insignificant. Of far greater importance is the sharp decline in percentage of infestation in the old area of heavy infestation. Mahoning, Columbiana, Carroll, and Tuscarawas declined from 41, 53, 63, and 42 to 3, 14, 13, and 24 per cent, respectively.

It is impossible at this time to say with certainty what factor or factors were responsible for the slump in infestation of the sawfly this season, although there is some evidence to indicate that parasitic insects may have been of considerable importance. Neither can a forecast be hazarded concerning the probable significance of the insect next season. It is to be hoped, however, that this new pest has reached its climax and that it will not be as destructive as its earlier behavior gave good reason to suspect.

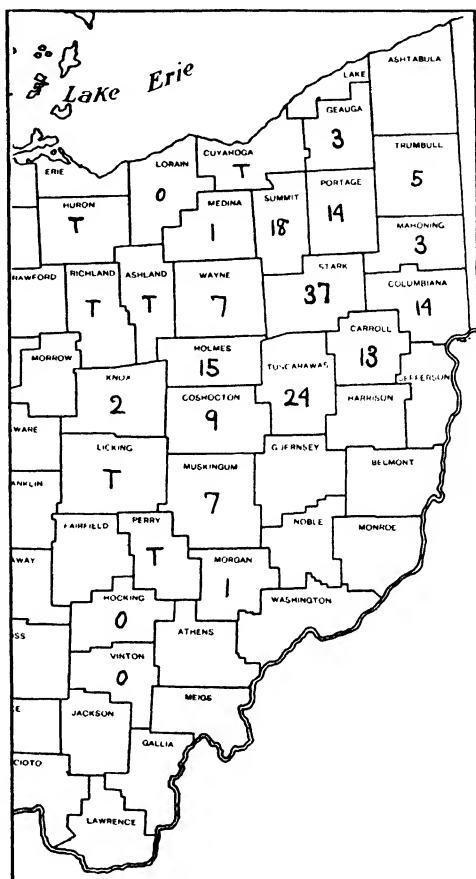


Fig. 1.—The figures in the counties indicate the average percentage of the wheat infested with black wheat-stem sawfly in 1938. The letter T signifies that less than 1 per cent was infested.

# EFFECT OF BASE AND SURPLUS PLANS ON VOLUME OF MILK SALES BY INDIVIDUAL PRODUCERS

R. W. SHERMAN

There is no accurate way to measure the effect of base and surplus milk buying plans on volume of shipments by producers. It has been demonstrated rather conclusively that these plans level out the year's sales, but effect on total yearly volume has been more difficult to analyze. It has been generally thought that the total sales or production might even be higher as a result of attempting to even out sales over the year.

A group of 374 milk producers from four Ohio markets who shipped milk continuously from 1927 to 1936 was selected for study of effect of base and surplus buying plans on volume. The sales of these producers were studied from the standpoint of what happened to their sales volume when they changed from a so-called summer producer to a winter producer and vice versa. Table 1 presents the number of producers who had a smaller or larger volume of sales accompanying both types of changes.

**TABLE 1.—Number of Producers, of a Sample of 374 Milk Producers of Four Ohio Markets, Changing from Summer to Winter and Winter to Summer Classifications and How Their Volume of Shipments Changed, by Years, 1927-1936**

Change from previous year	1927 to 1928	1928 to 1929	1929 to 1930	1930 to 1931	1931 to 1932	1932 to 1933	1933 to 1934	1934 to 1935	1935 to 1936	All years
Winter to summer										
Higher .....	30	37	28	18	35	34	61	37	44	324
Lower .....	26	28	18	27	28	22	16	40	22	227
Summer to winter										
Higher .....	22	22	50	24	15	21	32	11	43	240
Lower .....	42	32	38	68	55	39	27	30	36	367
Total.....	120	119	134	137	133	116	136	118	145	1158

An arbitrary method was used to classify the producers as summer or winter producers. If the November sales were less than 75 per cent of the June sales, the producer was classified as summer; if they were more than 75 per cent, the classification was winter. This classification was determined for each year.

As will be noted from Table 1 there were 1158 individual changes in classification from 1927 to 1936. Of these changes, 551 were from winter to summer. Of these changes 324 were accompanied by larger yearly sales and 227, by decreased yearly sales. There were 607 changes from summer to winter classification. In 367 of these changes the year's production decreased; in 240 it increased.

These changes in production would seem to indicate that the adherence to base and surplus plans was accompanied, to some degree, by lower sales. When each year's changes are analyzed it can be seen that 1931 and 1932—the years when base and surplus plans were in general use—showed an exceptionally high percentage of the producers changing to the winter classification, with lower sales.

Before it could be said that base and surplus plans were responsible for changes in production, other factors would have to be studied. How much milk was sold through other channels during surplus months would have to be known, also whether the producers had changed in a conscious attempt to adjust to the plan in use. The figures of Table 1 merely indicate that the sales through the regular channels decreased as a change from summer to winter classification came about and increased with changes from winter to summer classification.

# INDEX NUMBERS OF PRODUCTION, PRICES, AND INCOME

J. I. FALCONER

For the first 6 months of the year 1938, the income to the Ohio farmer from the sale of farm products was 18 per cent below that of the corresponding months of the preceding year. The price of Ohio farm products in June of 1938 was 23 per cent below that of a year earlier.

Trend of Ohio Prices and Wages, 1910-1914=100

	Wholesale prices, all commodities U. S.	Weekly earnings N. Y. State factory workers	Prices paid by farmers	Farm products prices U. S.	Ohio farm wages	Ohio farm real estate	Ohio farm products prices	Ohio cash income from sales
1913.....	102	.....	101	101	104	100	105	101
1914.....	99	100	100	101	102	102	105	108
1915.....	102	101	105	98	103	107	106	111
1916.....	125	114	124	118	113	113	121	121
1917.....	172	129	149	175	140	119	182	199
1918.....	192	160	176	202	175	131	203	240
1919.....	202	185	202	213	204	135	218	266
1920.....	225	222	201	211	236	159	212	226
1921.....	142	203	152	125	164	134	132	130
1922.....	141	197	149	132	145	124	127	130
1923.....	147	214	152	142	166	122	134	144
1924.....	143	218	152	143	165	118	133	146
1925.....	151	223	157	156	165	110	159	174
1926.....	146	229	155	145	170	105	155	177
1927.....	139	231	153	139	173	99	147	165
1928.....	141	232	155	149	169	96	154	156
1929.....	139	236	153	146	169	94	151	165
1930.....	126	226	145	126	154	90	128	137
1931.....	107	207	124	87	120	82	89	100
1932.....	95	178	107	65	92	70	63	73
1933.....	96	171	109	70	74	59	69	85
1934.....	110	182	123	90	77	63	85	98
1935.....	117	191	125	108	87	66	110	127
1936.....	118	199	124	114	100	71	118	147
1937.....	126	215	131	121	118	75	128	161
1936								
July.....	118	198	123	115	105	.....	121	189
August.....	119	202	126	124	.....	.....	131	183
September.....	119	198	127	124	.....	.....	127	169
October.....	119	202	127	121	108	.....	124	164
November.....	120	201	127	120	.....	.....	123	158
December.....	123	211	128	126	.....	.....	127	160
1937								
January.....	125	209	130	131	104	.....	128	151
February.....	126	211	132	127	.....	.....	127	141
March.....	128	218	132	128	.....	75	129	157
April.....	128	219	134	130	118	.....	134	170
May.....	127	219	134	128	.....	.....	135	164
June.....	127	220	134	124	.....	.....	134	162
July.....	128	218	133	125	123	.....	138	191
August.....	128	220	132	123	.....	.....	135	171
September.....	128	215	130	118	.....	.....	129	164
October.....	125	214	128	112	127	.....	123	156
November.....	122	205	127	107	.....	.....	116	156
December.....	119	207	126	104	.....	.....	114	142
1938								
January.....	118	201	126	102	115	.....	109	135
February.....	116	204	126	97	.....	.....	105	121
March.....	116	205	125	96	.....	74	106	130
April.....	115	204	125	94	116	.....	104	126
May.....	114	201	125	92	.....	.....	104	132
June.....	114	.....	124	92	.....	.....	106	134
July.....	.....	.....	.....	.....	119	.....	.....	.....





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## Ohio Agricultural Experiment Station

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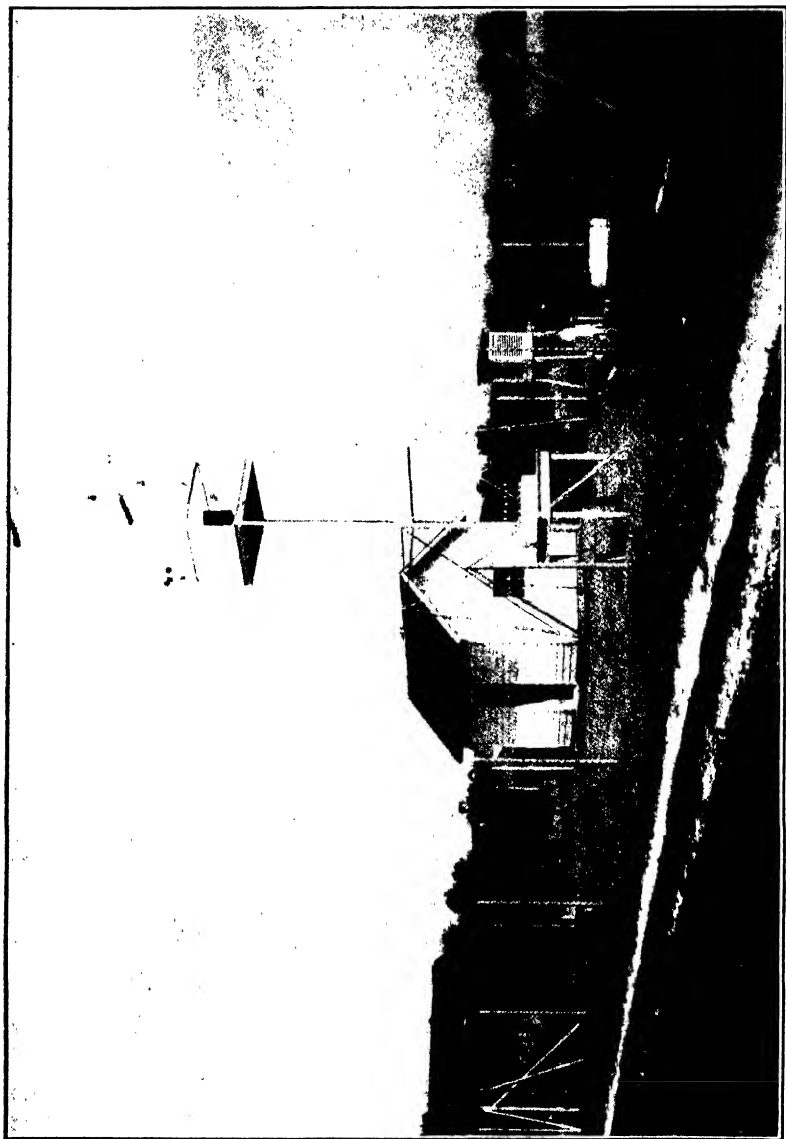
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# THE RATE OF SEEDING GRIMM AND COMMON ALFALFA<sup>1</sup>

C. J. WILLARD

Although alfalfa has been grown for many years in humid regions, the best rate of seeding continues to be a question. Eighteen as recent extension or popular experiment station publications from the humid states as could be obtained, recommended rates of seeding varying from 8 to 25 pounds per acre. Only six of these recommended rates below 15 pounds per acre as most satisfactory. There is, nevertheless, a distinct tendency for the recommended rates of seeding to be reduced in later years.

There is abundant evidence that the wider use of alfalfa in humid sections would be advantageous. Ask almost any group of farmers why more alfalfa is not grown, and the cost of seeding is usually raised as one major objection. Since for 20 years the price of alfalfa seed has averaged less than that of red clover, pound for pound,<sup>2</sup> this impression of a high cost of seeding must have its basis in the high rates of seeding generally recommended for alfalfa as compared with red clover.

Alfalfa seed is slightly larger than that of red clover, but this consideration could not account for an increase of more than one-fourth over the usual rate of seeding red clover, which varies from 6 to 10 pounds. Farmers cannot be blamed for hesitating to sow alfalfa when they are told that they must purchase 20 or 25 pounds of seed for an acre.

## PREVIOUS EXPERIMENTAL WORK

Earlier experiments at Wooster<sup>3</sup> indicated no advantage for rates of seeding alfalfa over 10 pounds per acre. Experiments on rate of seeding alfalfa in which tabulated yield data were presented have been noted from seven other states.<sup>4</sup> Several less completely reported experiments were also noted, but an exhaustive search of the literature was not attempted. Of the seven tests cited, three obtained the highest yield at a rate of 10 pounds per acre or less, and in three of the other four experiments the differences between the yields at 10

<sup>1</sup>These experiments were conducted at the Northwestern Experiment Farm, Holgate, Ohio, which was conducted cooperatively by the Division of Forage Crops and Diseases, U. S. Department of Agriculture, and the Department of Agronomy, Ohio Agricultural Experiment Station, during the period covered by these experiments.

Acknowledgment is due Mr. J. S. Cutler, in charge of agronomic experiments on the outlying Experiment Farms until March 1934, and Mr. J. B. McLaughlin, Superintendent of the Northwestern Experiment Farm during the period of these experiments, for their active cooperation.

<sup>2</sup>Willard, C. J., L. E. Thatcher, and J. S. Cutler. 1934. Alfalfa in Ohio. Ohio Agr. Exp. Sta. Bull. 540. Pages 48-49.

<sup>3</sup>Williams, C. G. 1917. Alfalfa culture. Ohio Agr. Exp. Sta. Mo. Bull. 18. Pages 173-178.

<sup>4</sup>Bergh, Otto I. 1930. Alfalfa trials at the North Central Experiment Station. Minn. Agr. Exp. Sta. Bull. 267.

Cocke, R. P. 1926. Experiments with alfalfa in eastern Virginia. Va. Agr. Exp. Sta. Bull. 247.

Neel, L. R. 1932. Spring seeding of alfalfa. Tenn. Agr. Exp. Sta. Cir. 40.

Rather, H. C. and others. 1936. Alfalfa in Michigan. Mich. Agr. Exp. Sta. Cir. Bull. 154.

Henson, Paul R. and H. L. Westover. 1935. Alfalfa experiments at Stoneville, Mississippi. U. S. D. A. Tech. Bull. 495.

Schoth, Harry A. and Geo. R. Hyslop. 1929. Alfalfa in western Oregon. Oregon Agr. Exp. Sta. Bull. 246.

Woodward, N. F. 1923. Experiments with alfalfa and grasses at the Judith Basin Substation. Montana Agr. Exp. Sta. Bull. 152.

pounds and at higher rates were not significant. Cocke obtained 40 to 50 per cent of weeds at 10 pounds per acre and only 3 to 5 per cent at 30 pounds per acre. He recommended 20 to 30 pounds of seed per acre. Only two (Rather and Bergh) of the seven recommended rates of seeding of 10 pounds or less. None of these authors reported any detailed studies of the effect of rate of seeding on the quality of hay, other than weed content.

## EXPERIMENTAL METHODS AND TECHNIQUE

The present study was undertaken to repeat the earlier Wooster experiments on another soil type, to include a comparison of Grimm and common alfalfas, and particularly to study the hay produced by the different rates of seeding. The earlier data from this experiment have already been reported.<sup>5</sup>

The soil at Holgate is a Brookston clay, a heavy, deep, black soil. Alfalfa was sown in the spring in a companion crop of 4 pecks of Fulghum or Franklin oats. Until the last 2 years of the test the seeding was made entirely by a 4-inch grass seed drill; in the last two seedings parallel series at the lower rates of seeding were sown broadcast. Nine rates of seeding, 2½, 5, 7½, 10, 12½, 15, 20, 25, and 50 pounds per acre, were used. The plots were sown in that order, except that the standard 10-pound rate was repeated between the 20- and 25-pound rates as plot 8, so that there were 10 plots in each series. One series was sown to Grimm and one to adapted common alfalfa each year, and in 1935 and 1936 a third series was sown to locally produced seed. The yield data from this seed in 1936 so exactly paralleled the others that they are omitted, but some other data from this variety are included in the averages.

The extreme rates of seeding obviously went beyond practical limits in both directions, but were included because it was thought that extremes might give a better indication of the effects of rate of seeding on the crop than a more practical range of seeding rates. The plots were 15 feet, 4 inches wide and 136 feet long, including a 24-inch border, until the 1935 and 1936 seedings, which were 8 feet wide, including a 16-inch border.

Yield estimates were obtained by taking four representative square-yard samples from each plot. These were, in general, systematically distributed through the plots, though because of the small number of samples taken, areas which were obviously better or worse than the majority of the plot were avoided. The stands were generally very uniform, so that this sampling method was satisfactorily accurate, as shown by studies in experimental technique made at Holgate.

The first seeding was made in July 1929, but the stands were so poor and uneven that no data were obtained from the plots. The first seeding reported was made in 1931. The original plan of the experiment was to take yields for only 1 year and make a new seeding each year. Because of the well-known ability of thin alfalfa stands to yield well in the second or later years, it was assumed that the greatest differences between rates of seeding would be obtained in the year after seeding. However, no seedings of any kind were made on the Farm in 1933, and the 1934 seeding failed on account of drouth. The 1932 seeding was exceptionally even and good (for the respective amounts sown) and was harvested through the 3 years 1933, 1934, and 1935. The 1935 and 1936 seedings included both drilled and broadcast plots of all varieties at

<sup>5</sup>Willard, C. J., L. E. Thatcher, and J. S. Cutler. 1934. Alfalfa in Ohio. Ohio Agr. Exp. Sta. Bull. 540. Pages 62-65. Willard, C. J., J. S. Cutler, and J. B. McLaughlin. 1934. The rate of seeding alfalfa. Ohio Agr. Exp. Sta. 52nd An. Rep., Bull. 532. Pages 28-29.

the rates up to 12½ pounds per acre. The heavier rates of seeding were drilled only. Yields were obtained from the 1935 seeding in 1936, and stand counts were made in the 1936 seeding that fall. Owing to changes at the Farm no data were taken in 1937 except notes and pictures.

Although three cuttings are often taken in the Holgate area, only two cuttings were harvested from this experiment each year, partly to reduce and distribute the amount of labor involved, partly because three of the five harvest seasons were so dry that no practical third cutting could be obtained. The first cutting included about 70 per cent of the total yield in the 3 dry years (1933, 1934, and 1936) and about 57 per cent in the 2 more favorable years (1932 and 1935). There was no difference in the relative yields of the different rates of seeding in the two cuttings, except a slight tendency in 1933 for the 2½-pound rate to yield more than the others in the second cutting.

### EXPERIMENTAL RESULTS

**Stands obtained.**—Data on stands obtained from the various rates of seeding were obtained by two methods. In 1932, 1933, 1934, and 1935 the stands were obtained by counting the plants in the square-yard samples dug to obtain root weights. This is accurate for the sample counted, but the samples were few and consequently the sampling error was large. In 1936 counts of the plants in place on the plots were made in four distributed square-foot areas. This method is highly inaccurate, especially for the thicker stands, because of the difficulty in identifying single plants. The 1936 data are worth while in comparing the drilled and broadcast seedings, but there were certainly more plants in the plots sown at the thicker rates in 1935 than these counts indicate. No stand records were made in 1931. All counts were made late in the fall (Table 2).

**TABLE 1.—Stands of Alfalfa Obtained at Various Rates of Seeding**

Data obtained from two square-yard samples from each plot of Grimm and common in 1932, one square-yard sample from each plot of Grimm and common in 1933, 1934, and 1935, except as noted, and four samples of 1 square foot from each plot of each of three varieties in 1936

Rate of seeding per acre	Plants per square yard, average all varieties								
	1931 seeding	1932 seeding				1935 seeding		1936 seeding*	
	1932	1932	1933	1934	1935	1935		1936	
						Drilled	Broad- cast	Drilled	Broad- cast
<i>Lb.</i>	<i>No.</i>	<i>No.</i>	<i>No.</i>	<i>No.</i>	<i>No.</i>	<i>No.</i>	<i>No.</i>	<i>No.</i>	<i>No.</i>
2½.....	72	102	80	68	38	40†	58†	68	106
5.....	96	98	80	64	44	62†	60†	77	145
7½.....	185	156	148	115	73	176†	126†	67	155
10.....	190	213	172	139	88	131†	177†	107	179
10.....	178	218	140	123	108	142	.....	134	.....
12½.....	234	339	231	177	121	234†	156†	85	170
15.....	226	385	296	190	106	275	.....	120	.....
20.....	290	480	406	251	166	350	.....	125	.....
25.....	284	672	362	236	166	398	.....	156	.....
50.....	331	963	525	251	206	524	.....	179	.....
Average.....	.....	.....	.....	.....	.....	129†	115†	81†	151†

\*Counted in place, see text.

†One square-yard sample of Grimm only.

‡Comparable plots.

The stand data obtained are presented in Tables 1 and 2. Table 1 gives a good idea of the stands from which these data were obtained. The effect of rate of seeding on the thinning out of the stands from year to year is given by the 4 years' records from the 1932 seeding. In the early Wooster work the stands soon became substantially identical; at Holgate the differences were still outstanding after 3 years of cutting (Fig. 1). The prevailing dry seasons from 1932 to 1935 may account for this difference. The differences in stand between Grimm and common (Table 2) show that Grimm generally had a thicker stand, but not enough to be attributed to the variety instead of the particular samples of seed sown.

TABLE 2.—Plants per Square Yard and Weight of Roots per Acre,  
Grimm and Common Alfalfa

Averages of all rates of seeding

Year sown	Date of digging roots	Plants per square yard, average of 10 plots at different rates		Yield of air-dry roots per acre, average of all plots	
		Grimm	Common	Grimm	Common
		No.	No.	Lb.	Lb.
1931	Nov. 1932	242	175	3560	2720
1932	Nov. 1932	384	341	1630	1610
1932	Sept. 20, 1933	294	194	3120	2490
1932	Sept. 27, 1934	176	147	4660	4310
1932	Oct. 16, 1935	122	101	3760	3540
1935	Oct. 16, 1935	324*	352*	340*	290*
1936	Nov. 1936†	110†	142†	Not determined	

\*10-, 15-, 20-, 25-, and 50-pound rates only.

†Plants counted in place.

**Yields.**—Yields are reported in Table 3 for the average of Grimm and common alfalfa for each year, for the series of 5 years, for the 3 years immediately after the seeding year, and for the 2 later years after seeding. These data in 1936 are for the drilled plots only, in order to make the averages comparable with the preceding years. The data for plots 4 and 8, sown at 10 pounds per acre, were not combined, since their variation gives a ready measure under the conditions of the experiment of the possible differences in plots treated alike.

TABLE 3.—Total Yield of Hay per Acre for the Year,  
Alfalfa Sown at Different Rates

Averages of Grimm and common

Rate of seeding per acre	Yield per acre						
	1931 seeding	1932 seeding			1935 seeding	Average 1932 to 1936	Average 1932, 1933, and 1936
	1932	1933	1934	1935	1936		
Lb.	Lb.	Lb.	Lb.	Lb.	Lb.	Lb.	Lb.
2½.....	3890	2760	4520	6660	2610	4080	5590
5.....	4150	2720	3980	7780	3060	4340	5880
7½.....	4560	2940	4380	8000	3020	4580	6190
10.....	4540	3120	4320	7680	2850	4500	6000
10.....	4460	3440	4420	8240	2640	4630	6330
12½.....	4820	3180	4420	8360	2760	4710	6390
15.....	4760	3270	4260	7600	2870	4560	5930
20.....	4490	3320	4340	8100	2450	4540	6220
25.....	4490	3560	4520	8220	2490	4660	6370
50.....	4360	3400	4500	8270	2410	4590	6340
Average of all rates	4460	3170	4360	7890	2720	4520	6120

The data in Table 3 justify the conclusion that the yield from no rate of seeding except  $2\frac{1}{2}$  pounds differs significantly from any other, though the yield from 5 pounds is slightly lower than the other rates in most years and would probably be significantly so in a longer series of experiments. It is important to note in studying rates of seeding alfalfa that stands which appear thin to the eye (Fig. 1) may yield as much or nearly as much as thicker stands.

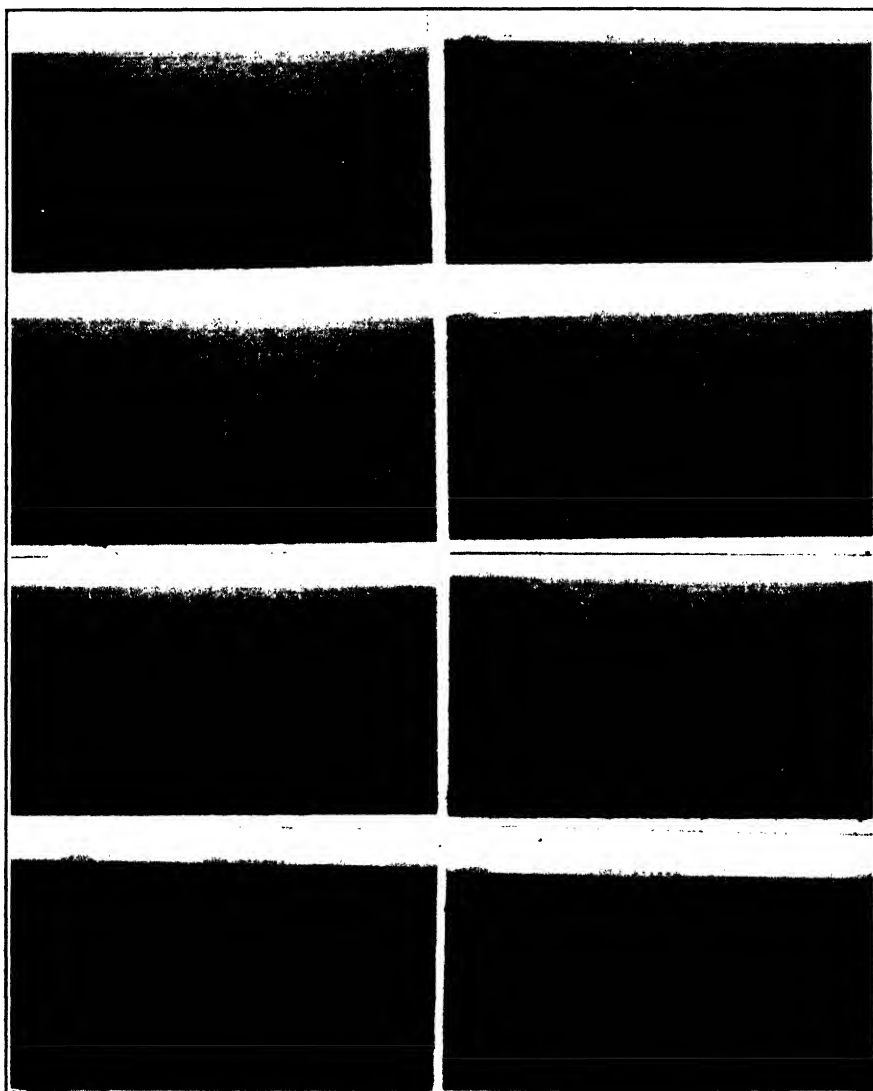


Fig. 1.—General appearance of the plots of common alfalfa in the 1932 seeding, May 13, 1935

Left, top to bottom, plots sown at  $2\frac{1}{2}$ , 5,  $7\frac{1}{2}$ , and 10 pounds per acre; right, top to bottom, plots sown at  $12\frac{1}{2}$ , 15, 20, and 50 pounds per acre

**Weed infestation.**—There was no appreciable weed infestation in any of the plots at any time. In central and southern Ohio, where winter annual weeds are a pressing problem, the bare places left in the thinner stands might have permitted establishment of such weeds. However, the use of alfalfa-grass mixtures<sup>6</sup> is a more practical solution of the weed problem than heavy rates of seeding alfalfa.

**Effect of variety.**—Some publications<sup>7</sup> state that Grimm or other variegated alfalfas may be sown at lower rates than common alfalfa. In Table 4 the yields of Grimm and common are averaged separately for the same groups of years as the total yields, and the yield of common is calculated as a percentage of the yield of Grimm for each set of averages.

TABLE 4.—Yields of Hay from Grimm and Common Alfalfa  
Sown at Different Rates

Rate of seeding per acre	Average total yield per acre per year								
	5 years, 1932-1936			First year after seeding, 3 years, 1932, 1933, and 1936			Second and third years after seeding, 1934 and 1935		
	Grimm	Com- mon	Common Grimm = 100	Grimm	Com- mon	Common Grimm = 100	Grimm	Com- mon	Common Grimm = 100
<i>Lb.</i>	<i>Lb.</i>	<i>Lb.</i>	<i>Pct.</i>	<i>Lb.</i>	<i>Lb.</i>	<i>Pct.</i>	<i>Lb.</i>	<i>Lb.</i>	<i>Pct.</i>
2½.....	4310	3860	90	3210	2960	92	5950	5220	88
5.....	4830	3850	80	3700	2930	79	6540	5240	80
7½.....	4970	4190	84	3880	3130	81	6590	5790	88
10.....	4730	4280	90	3800	3210	84	6120	5880	96
10.....	5010	4250	85	3910	3100	79	6670	5980	90
12½.....	5040	4380	87	3960	3210	81	6650	6120	92
15.....	5060	4050	80	4140	3120	75	6420	5430	85
20.....	4970	4110	83	3840	2990	80	6660	5780	87
25.....	4990	4320	87	3850	3180	83	6700	6040	90
50.....	4920	4260	87	3820	2960	77	6570	6200	94
Average....	4880	4160	85	3820	3080	81	6480	5760	89

These percentages show that although Grimm outyielded common, as it practically always does in this section of the State, it did so rather uniformly at each rate of seeding, and there is no apparent difference in the most desirable rate of seeding for either type.

In view of the opinion generally held, that Grimm is particularly valuable for long-time stands, it may be noted that the superiority of Grimm was greater in the year after seeding than in the later years.

**Effect of method of seeding.**—Some authors<sup>8</sup> recommend lower rates of seeding for drilling than for broadcasting. In the 1935 and 1936 seedlings the five lower rates were sown by both methods. No data except stands, as reported in Table 1, were taken from the 1936 series; the yields of hay per acre in 1936 for the different methods of seeding in 1935 are summarized in Table 5. The poorer stands from broadcasting in 1935 resulted from sowing the alfalfa

<sup>6</sup>Thatcher, L. E., C. J. Willard, and R. D. Lewis. 1937. Better methods of seeding meadows. Ohio Agr. Exp. Sta. Bull. 588. Page 54.

<sup>7</sup>Dalton, L. A. 1924. Alfalfa production for New York. Cornell Ext. Bull. 84. Decker, R. E. More alfalfa for Michigan. Mich. Ext. Bull. 23 (revised, 1931).

<sup>8</sup>Kiesselbach, T. A. and Arthur Anderson. 1927. Alfalfa in Nebraska. Neb. Agr. Exp. Sta. Bull. 222.

Lewis, R. D., J. A. Slipper, and C. J. Willard. Alfalfa in Ohio farming. Ohio Agr. Ext. Serv. Bull. 137 (revised, 1935).

Schoth, Harry A. and Geo. R. Hyslop. 1929. Alfalfa in western Oregon. Oregon Agr. Exp. Sta. Bull. 246.

Throckmorton, R. I. and S. C. Salmon. 1927. Alfalfa production in Kansas. Kansas Agr. Exp. Sta. Bull. 242.

TABLE 5.—Drilling versus Broadcasting Alfalfa at Different Rates, 1936 Seeding

Averages of three sources of seed at each rate

Rate of seeding per acre	Yields of hay per acre, total of both cuttings, 1936	
	Drilled	Broadcast
<i>Lb.</i>	<i>Lb.</i>	<i>Lb.</i>
2½.....	2620	2600
5.....	2950	3060
7½.....	2950	2930
10.....	2990	2960
12½.....	2880	2870
Average.....	2880	2890

in oats on June 1, nearly a month after the oats were sown. In most seasons no stand would have been obtained under such conditions from broadcasting without covering the seed in any way, and it is not surprising that drilling gave the better stands. Drilling would not cover too deep on such a settled soil, yet would permit some coverage. Despite the difference in stands, the yields in 1936 from drilling and broadcasting were practically identical (Table 5). In 1936 the alfalfa was sown the same day the oats were sown. The drill evidently placed many of the seeds too deep. Seed broadcast on loose ground, covered by timely rains, made a much higher percentage of establishment (Fig. 2) (Table 1).

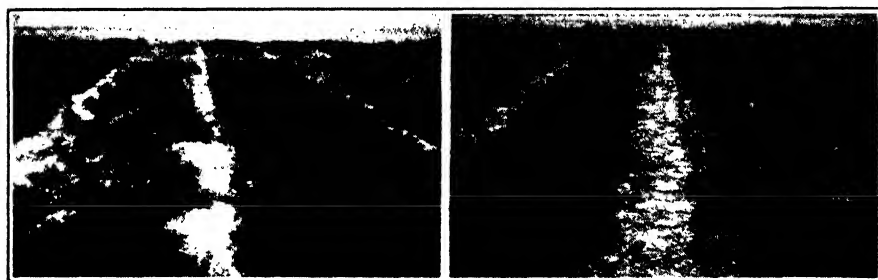


Fig. 2.—Contrasting results of drilling and broadcasting under different conditions

May 11, 1937. All plots sown to common alfalfa at 7½ pounds per acre. Left, 1935 seeding, made on solid crusted ground some time after the oats were sown; right, 1936 seeding, made in loose ground the day the oats were sown. In each picture: left, broadcast; right, drilled

The conclusion is that drilling or broadcasting as such does not affect the rate of seeding. Poor methods of seeding obviously require higher rates of seeding than good methods, but either drilling or broadcasting may be the poorer method, depending on conditions.<sup>9</sup> It is probable that some of the rather excessive rates of seeding recommended reflect the general use of poor seeding methods, methods not adapted to alfalfa, or poor seeding conditions. However, using more seed as a substitute for good seeding methods very quickly reaches the point of diminishing returns (Fig. 3).

<sup>9</sup>Thatcher, L. E., C. J. Willard, and R. D. Lewis. 1937. Better methods of seeding meadows. Ohio Agr. Exp. Sta. Bull. 588. Pages 39-41.



Fig. 3.—More seed makes up for poor seeding method.

May 11, 1937. Common alfalfa drilled in loose ground in 1936. Left, 10 pounds per acre; right, 20 pounds per acre. Compare these with the extreme right of Figure 2, sown in the same way at 7½ pounds. No yields were obtained from these plots, but from past experience, it is not likely that there was any increase in yield above 10 pounds of seed per acre.

**Height of plants.**—The height of the stands sown at different rates is reported in Table 6. There was a definite tendency, which was conspicuous in the field, for the plots from thick rates of seeding to be shorter in dry years. In favorable years (1935, first cutting in 1934) there was little if any difference in the height of the plots. Heights were not recorded in 1932.

TABLE 6.—Height of Alfalfa Stands Sown at Different Rates  
Averages of Grimm and common

Rate of seed- ing per acre	Height of plants									
	First cutting					Second cutting				
	1933	1934	1935	1936	Average	1933	1934	1935	1936	Average
<i>Lb.</i>	<i>In.</i>	<i>In.</i>	<i>In.</i>	<i>In.</i>	<i>In.</i>	<i>In.</i>	<i>In.</i>	<i>In.</i>	<i>In.</i>	<i>In.</i>
2½.....	19	23	35	23*	25.0	8	16	24	11*	14.8
5.....	19	24	37	20*	25.0	8	16	26	10*	14.5
7½.....	18	24	36	19*	24.2	7	16	26	10*	14.8
10.....	18	24	35	19*	24.0	7	15	26	10*	14.5
10.....	18	24	35	19	24.0	7	14	27	10	14.5
12½.....	18	24	36	19*	24.2	7	15	26	10*	14.5
15.....	18	23	36	18	23.8	7	15	26	9	14.2
20.....	18	24	36	16	23.5	7	14	26	10	14.2
25.....	17	24	35†	18	23.5	7	14	26	9	14.0
50.....	17	24	35†	18	23.5	7	13	24	8	13.0

\* Average of three varieties.

† Estimated, not recorded.

There was no significant or constant difference in the heights of Grimm and common alfalfa.

**Texture of the hay.**—An effect of heavy seeding which many consider valuable is that it results in finer-stemmed hay. This is obvious in the field, but several different measures were used in obtaining quantitative expressions of the fact.

**Diameter of the dry stems.**—The diameter of the dry stems at the point of cutting was obtained with a vernier caliper for the crops of 1933, 1934, and 1935. The first year two random samples of 25 stems from each of two areas in the plot were measured, the other 2 years a random sample of 100 stems from each plot. The distribution of the individual measures has been studied, and the sampling is reasonably satisfactory, though a larger number of measurements would have been better. The data, as reported in Table 7, show that there is a decided difference in the diameter of stems from the different rates of seeding in the year after seeding, that this difference becomes less in successive later years, and that the diameter of the stems in plots from all rates of seeding increases as the stand grows older.

**TABLE 7.—Average Diameter of Dry Stems at Base, Alfalfa Sown at Different Rates in 1932**

Averages of Grimm and common. Average of 50 stems from each plot in 1933, 100 in 1934 and 1935

Rate of seeding per acre	Diameter of dry stems at base					
	First cutting			Second cutting		
	1933	1934	1935	1933	1934	1935
<i>Lb.</i>	<i>cm.</i>	<i>cm.</i>	<i>cm.</i>	<i>cm.</i>	<i>cm.</i>	<i>cm.</i>
2½.....	0.189	0.198	0.241	0.118	0.145	0.182
5.....	.181	.212	.240	.112	.143	.183
7½.....	.183	.206	.221	.103	.140	.180
10.....	.174	.212	.226	.104	.136	.178
10.....	.165	.190	.212	.110	.133	.177
12½.....	.173	.187	.204	.098	.131	.183
15.....	.173	.185	.224	.101	.133	.177
20.....	.159	.180	.212	.096	.129	.171
25.....	.147	.176	.210	.094	.119	.173
50.....	.148	.174	.224	.098	.123	.177

There was little difference between Grimm and common, as evidenced by the summary in Table 8. The stems of Grimm were uniformly slightly finer, as would be expected, since in this year's seeding thicker stands of Grimm were consistently obtained.

TABLE 8.—Comparisons of Grimm and Common Alfalfa  
in Rate of Seeding Experiment

Averages of 10 plots sown at rates ranging from 2½ to 50 pounds per acre

Year	First cutting		Second cutting	
	Grimm	Common	Grimm	Common
Diameter of dry stems at base				
	<i>Cm.</i>	<i>Cm.</i>	<i>Cm.</i>	<i>Cm.</i>
1933.....	0.168	0.170	0.103	0.104
1934.....	.191	.193	.128	.139
1935.....	.216	.227	.177	.179
Average.....	.192	.197	.136	.141
Stems per square yard				
	<i>No.</i>	<i>No.</i>	<i>No.</i>	<i>No.</i>
1933.....	275	256	354	272
1934.....	331	264	453	352
1935.....	294	231	280	254
1936.....	350	273	456	380
Average.....	313	256	386	315
Average weight of each stem				
	<i>Gm.</i>	<i>Gm.</i>	<i>Gm.</i>	<i>Gm.</i>
1933.....	0.77	0.73	0.25	0.26
1934.....	.87	.88	.26	.33
1935.....	1.53	1.67	1.13	1.06
1936.....	.48	.53	.18	.19
Average.....	.91	.95	.46	.46
Leaves in the hay				
	<i>Pct.</i>	<i>Pct.</i>	<i>Pct.</i>	<i>Pct.</i>
1932.....	53.6	56.9	55.6	55.9
1933.....	48.2	50.1	65.7	65.4
1934.....	44.2	46.9	53.0	51.8
1935.....	35.6	39.2	43.8	49.4
1936.....	53.2	52.5	54.2	52.0
Average.....	47.0	49.1	54.5	54.9
Protein in the hay				
	<i>Pct.</i>	<i>Pct.</i>	<i>Pct.</i>	<i>Pct.</i>
1932.....	19.6	21.1	16.7	.....
1933.....	16.7	17.3	18.4	18.2
1934.....	18.8	17.7	16.6	15.9
1935.....	15.7	15.7	16.2	17.2
Average.....	17.9	17.9	17.1*	17.1

\*1932 omitted.

**Number of stems per unit area.**—This gives an important measure of texture. Since the yields were nearly equal, the more stems the finer the hay. In 1933 the stems were counted in a dried sample which had been carefully taken and preserved. Because of the brittleness of the dry stems this proved unsatisfactory and somewhat inaccurate; so in 1934, 1935, and 1936, the stems were counted in green samples just as cut for yield estimates.

The data are reported in Table 9. The data for 1933 are given as obtained, but are probably low. There is a great variation in the number of stems from plots sown at different rates in the first years after seeding (1933 and 1936), but the number tends to become uniform in the later years of the stands. Except in 1935, there were always more stems in the second cutting than in the first.

**TABLE 9.—Number of Stems per Square Yard in Alfalfa Sown at Different Rates**

Averages of two square-yard samples each of Grimm and common alfalfas

Rate of seeding per acre	Stems per square yard									
	1933		1934		1935		1936*		Average	
	First cut- ting	Second cut- ting	First cut- ting	Second cut- ting	First cut- ting	Second cut- ting	First cut- ting	Second cut- ting	First cut- ting	Second cut- ting
<i>Lb.</i>	<i>No.</i>	<i>No.</i>	<i>No.</i>	<i>No.</i>	<i>No.</i>	<i>No.</i>	<i>No.</i>	<i>No.</i>	<i>No.</i>	<i>No.</i>
2½.....	153	224	210	312	156	231	190	254	177	255
5.....	175	242	194	288	219	236	235	346	206	278
7½.....	242	278	254	351	232	259	246	398	244	322
10.....	233	312	272	356	246	270	278	393	257	333
10.....	249	299	290	421	284	264	282	393	276	344
12½.....	270	342	292	401	251	298	326	432	285	368
15.....	284	314	310	424	284	273	371	488	312	375
20.....	310	355	353	458	314	296	358	439	334	387
25.....	327	383	368	497	309	267	342	460	337	402
50.....	411	383	430	517	325	275	442	520	402	424

\* 1936 data for rates from 2½ pounds to 12½ pounds are averages of three varieties each at two methods of seeding. Twelve samples in all.

The number of stems per square yard is less variable at different rates of seeding than the number of plants per square yard. It is possible to calculate from Tables 1 and 9 the number of stems per plant at the different rates of seeding; when this was done the number varied from almost exactly one at the higher rates to three to four at the two lowest rates after the first year.

There were always more stems of Grimm than of common at any given rate, as reported in Table 8.

**Average weight of each stem.**—This is given in Table 10, and gives an absolute measure of the relative fineness of the hay from the different plots. These data also show that the thick rates of seeding produced much finer stems in the year after seeding, and that the differences became less as the stands grew older.

**TABLE 10.—Average Weight of Each Stem of Alfalfa Sown at Different Rates**  
Averages of Grimm and common

Rate of seeding per acre	Average weight of each stem							
	First cutting				Second cutting			
	1933	1934	1935	1936	1933	1934	1935	1936
<i>Lb.</i>	<i>Gm.</i>	<i>Gm.</i>	<i>Gm.</i>	<i>Gm.</i>	<i>Gm.</i>	<i>Gm.</i>	<i>Gm.</i>	<i>Gm.</i>
2½.....	0.99	0.90	2.15	0.68	0.40	0.38	1.07	0.35
5.....	.89	1.19	1.81	.69	.34	.41	1.20	.29
7½.....	.78	1.05	1.68	.65	.25	.33	1.20	.25
10.....	.83	.97	1.60	.60	.26	.32	1.03	.22
10.....	.89	.90	1.47	.58	.27	.30	1.15	.19
12½.....	.72	.92	1.65	.51	.25	.27	1.06	.20
15.....	.74	.83	1.36	.48	.25	.28	1.02	.15
20.....	.70	.73	1.35	.43	.21	.27	.97	.14
25.....	.71	.76	1.36	.43	.21	.24	1.13	.15
50.....	.55	.63	1.26	.33	.19	.24	1.15	.12

TABLE 11.—Percentage of Leaves in Alfalfa Hay from Plots Sown at Different Rates  
Averages of Grimm and common

Rate of seeding per acre	Leaves in the hay													
	First cutting							Second cutting						
	1932	1933	1934	1935	1936	Average 1932-1936	Average 1932, 1933, and 1936	1932	1933	1934	1935	1936	Average 1932-1936	Average 1932, 1933, and 1936
<i>Lb.</i>	<i>Pct.</i>	<i>Pct.</i>	<i>Pct.</i>	<i>Pct.</i>	<i>Pct.</i>	<i>Pct.</i>	<i>Pct.</i>	<i>Pct.</i>	<i>Pct.</i>	<i>Pct.</i>	<i>Pct.</i>	<i>Pct.</i>	<i>Pct.</i>	<i>Pct.</i>
2½	55	50	45	39	51	48.0	52.1	55	66	50	50	57	55.6	59.3
5	55	49	42	38	51	47.0	51.9	55	67	47	48	58	54.9	59.9
7½	55	48	44	36	53	47.5	52.3	54	68	51	47	53	54.8	58.4
10	55	49	44	41	52	48.3	52.2	59	65	55	47	52	55.4	58.2
10	55	47	46	39	53	48.1	51.7	57	64	52	47	49	53.9	57.3
12½	56	50	46	36	54	48.1	52.9	55	65	50	44	51	53.1	57.1
15	55	50	48	36	53	48.3	52.5	56	66	53	47	50	54.4	57.3
20	56	49	49	37	53	48.9	52.7	56	65	52	45	54	54.3	58.1
25	54	49	45	36	51	47.0	51.4	53	64	58	45	56	55.3	57.8
50	56	50	47	36	57	49.3	54.4	58	65	54	47	51	54.8	58.2
Average.....	55.3	49.9	45.6	37.4	52.8	48.0	52.4	55.8	65.5	52.4	46.6	53.1	54.7	58.2

**Percentage of leaves in the hay.**—It has been generally assumed that the fact that thick planting gave fine-stemmed hay meant that there was a higher percentage of leaves in such hay. The percentage of leaves in the hay has been determined for each variety, cutting, and rate of seeding in the experiment. The averages of Grimm and common for each year and cutting, the averages for the 5 years, and the averages for the 3 years immediately after the seeding year are reported in Table 11. The results were calculated to 0.1 per cent, but this place is not significant in the averages of two to six determinations represented in the data for each rate in each year and is retained only in the final averages.

It is evident from Table 11 that there was no consistent effect of rate of seeding on the percentage of leaves in the crop harvested.

As reported in Table 8, common alfalfa was consistently higher in percentage of leaves than Grimm, except in 1936. The differences were usually statistically significant for these particular seedings, but it would be decidedly unsafe to generalize from them.

**Protein in the hay.**—Except for common alfalfa in the second cutting in 1932, the percentage of crude protein in the hay was also determined for both varieties and both cuttings until 1936, when no analyses were made. The averages of Grimm and common are given in Table 12.

TABLE 12.—Percentage of Crude Protein in Alfalfa Hay from  
Plots Sown at Different Rates  
Averages of Grimm and common

Rate of seeding per acre	Protein in the hay									
	First cutting					Second cutting				
	1932	1933	1934	1935	Av.	1932*	1933	1934	1935	Av.
<i>Lb.</i>	<i>Pct.</i>	<i>Pct.</i>	<i>Pct.</i>	<i>Pct.</i>	<i>Pct.</i>	<i>Pct.</i>	<i>Pct.</i>	<i>Pct.</i>	<i>Pct.</i>	<i>Pct.</i>
2½	19.7	17.6	18.5	16.6	18.1	16.6	17.2	18.0	16.4	17.2
5	19.6	17.4	19.4	15.4	17.9	16.9	17.6	15.2	17.2	16.7
7½	20.4	17.2	17.8	16.2	17.9	17.0	18.8	15.0	17.0	16.9
10	20.6	17.4	18.4	15.6	18.0	17.0	18.6	16.5	16.9	17.3
10	20.4	17.4	17.4	15.0	17.6	16.9	18.2	16.4	17.0	17.1
12½	20.4	17.2	18.6	15.9	18.0	16.9	18.5	15.6	16.3	16.8
15	20.4	17.6	18.0	15.8	18.0	16.6	18.7	16.0	16.4	17.0
20	20.8	17.3	18.0	15.5	17.9	16.2	18.6	15.2	16.8	16.8
25	20.4	17.4	18.4	15.7	18.0	16.2	18.4	17.5	16.4	17.3
50	20.7	17.6	17.9	15.6	17.9	16.6	18.4	17.3	16.8	17.4
Average	20.3	17.4	18.2	15.7	17.9	16.7	18.3	16.3	16.7	17.0

\*Grimm only.

Again no consistent differences between the different rates of seeding appear, and it seems that rate of seeding did not affect the protein content.

The differences in the protein content of Grimm and common alfalfa as given in Table 8 are not conclusive, though every pair of samples but one showed a difference in the indicated direction in the first cuttings of 1932 and 1934 and the second cutting of 1935. It is unlikely that these differences arose by chance, but their meaning apart from the particular pairs of strains used and the particular seasons studied, remains in doubt.

**Weight of roots.**—Alfalfa roots have a definite favorable effect on the soil. Presumably that effect is at least partially in proportion to the amount of roots produced. Estimates of the amount of roots per acre were made from 1932 to 1935 by digging square-yard samples in the fall to a depth of 10 inches. In 1932 both the 1931 and 1932 seedings were sampled. The 1932 seeding was also sampled in 1933, 1934, and 1935, and the 1935 seeding was sampled that fall. The average yields per acre of Grimm and common are reported in Table 13; the average weight per root is reported in Table 14; and a summary of the Grimm-common comparisons, in Table 2.

**TABLE 13.—Weight of Air-dry Roots per Acre of Alfalfa  
Sown at Different Rates**

Averages of Grimm and common. Data obtained from two square-yard samples from each plot of Grimm and common in 1932, and one square-yard sample from each plot in 1933, 1934, and 1935

Rate of seed- ing per acre	Weight of air-dry roots per acre						Average*
	Sown 1931	Sown 1932				Sown 1935	
	Nov. 1932	Nov. 1932	Sept. 20, 1933	Sept. 27, 1934	Oct. 15, 1935	Oct. 17, 1935	
<i>Lb.</i>	<i>Lb.</i>	<i>Lb.</i>	<i>Lb.</i>	<i>Lb.</i>	<i>Lb.</i>	<i>Lb.</i>	<i>Lb.</i>
2½.....	2480	1230	2260	3880	2620	250†	2490
5.....	2870	1120	2260	4100	3200	240†	2710
7½.....	3120	1280	2830	4400	3000	390†	2930
10.....	3070	1460	2740	4540	3990	380†	3160
10.....	3180	1530	2880	4120	3300	260	3000
12½.....	3480	1580	2880	5200	4210	430†	3470
15.....	3250	2140	2970	4860	3440	330	3330
20.....	3420	1950	3200	5100	4500	300	3624
25.....	3170	2080	2980	4380	4000	320	3320
50.....	3340	1910	3040	4260	4260	340	3340
Average.....	3140	1620	2800	4480	3650	310	3140

\*1935 seeding omitted.

†Average Grimm, drilled and broadcast.

**TABLE 14.—Average Dry Weight per Root of Alfalfa Sown at Different Rates  
Averages of Grimm and common**

Rate of seeding per acre	Dry weight per root					
	Sown 1931	Sown 1932				Sown 1935
	Nov. 1932	Nov. 1932	Sept. 20, 1933	Sept. 27, 1934	Oct. 15, 1935	Oct. 17, 1935
<i>Lb.</i>	<i>Gm.</i>	<i>Gm.</i>	<i>Gm.</i>	<i>Gm.</i>	<i>Gm.</i>	<i>Gm.</i>
2½.....	3.00	1.08	2.51	5.08	6.04	0.47*
5.....	2.62	1.02	2.49	5.67	6.24	.34*
7½.....	1.23	0.72	1.71	3.45	3.59	.22*
10.....	1.42	0.62	1.42	2.88	3.98	.22*
10.....	1.54	0.64	1.80	2.95	2.70	.18
12½.....	1.30	0.41	1.09	2.63	3.08	.20*
15.....	1.32	0.50	0.91	2.26	2.86	.10
20.....	1.04	0.35	0.73	1.79	2.39	.08
25.....	0.97	0.27	0.72	1.64	2.17	.06
50.....	0.88	0.16	0.53	1.48	1.83	.06

\*Average of Grimm, drilled and broadcast.

There is a sharp contrast between the amount of roots in the two new seedings, 1932 and 1935. The 1932 seeding was made early under good conditions; the 1935 seeding, on June 1 under poor conditions. The 1935 seeding gave much poorer average stands.

An earlier study<sup>10</sup> had shown a greater correlation between stand and yield of roots than between stand and yield of tops, and in this study there is more evidence of relation between rate of seeding and yield of roots than between rate and yield of tops. However, there certainly is no significant increase in yield of roots above a rate of seeding of 12½ pounds, and it is not certain, in view of the small number of samples represented, that the yields of any rates above 5 pounds per acre differ significantly. The effect of the dry seasons<sup>11</sup> of 1933 and 1934 in building up root reserves, and the moist season of 1935 in drawing on them, is well illustrated by the data.

**Weight of single roots.**—The average weight of the roots from the different plots, reported in Table 14, gives a measure of the effect of seeding rate on the individual plant; the heavier rates, of course, resulted in smaller plants. In the new seedings of 1932 and 1935, there is much less contrast between the weights of individual roots than between the total weight of roots. The individual roots of common alfalfa were always heavier than Grimm, except in the 1931 seeding, where they were equal. This suggests that the differences in yield of roots between Grimm and common were due to the better average stands of Grimm obtained. Other studies<sup>12</sup> have shown no consistent differences between the total weight of roots of Grimm and common alfalfa.

**Summary.**—Five years' results from four seedings of Grimm and common alfalfa at rates ranging from 2½ to 50 pounds of seed per acre gave the following conclusions:

1. There was no significant increase in yield of hay per acre for rates of seeding above 7½ pounds per acre.

2. There was no significant difference in the most desirable rate of seeding Grimm and common alfalfas; Grimm outyielded common by very similar percentages at all rates.

3. Neither drilling nor broadcasting as such affected the most favorable rate of seeding. The more favorable the method of seeding, the lower the satisfactory rate of seeding, but drilling is not the most favorable method under all conditions.

4. The hay from the thick rates was considerably finer than that from the thin rates, especially in the year after seeding. In the thick stands there were many more stems on a given area, the stems were smaller in diameter, and each stem weighed decidedly less than in the thin stands.

5. There were no significant differences in the percentage of leaves or in the percentage of protein in the hays from different rates of seeding.

6. There was no significant increase in the weight of air-dry roots per acre for rates of seeding above 12½ pounds per acre.

7. The average standard rate of seeding alfalfa in Ohio is 10 to 12 pounds per acre. Seven pounds is sufficient under the best seeding conditions; if conditions are so poor that 15 pounds per acre will not give a satisfactory stand, something other than the rate of seeding needs correction.

<sup>10</sup>Willard, C. J. 1931. The correlation between stand and yield of alfalfa and sweet clover. Jour. Agr. Res. 43: 461-464.

<sup>11</sup>Willard, C. J., L. E. Thatcher, and J. S. Cutler. 1934. Alfalfa in Ohio. Ohio Agr. Exp. Sta. Bull. 540. Pages 65, and 115-118.

<sup>12</sup>Willard, C. J., L. E. Thatcher, and J. S. Cutler. 1934. Alfalfa in Ohio. Ohio Agr. Exp. Sta. Bull. 540. Table 28.

# **PRESENT CULTURAL METHODS IN GROWING THE SPRING GREENHOUSE TOMATO CROP IN OHIO**

**I. C. HOFFMAN**

The early spring and summer greenhouse tomato crop is one of the most important forcing crops in Ohio and because of the controlled conditions many questions and problems have arisen in its culture. It has always been difficult to get the very early fruits to develop, and until recently it was likewise difficult to get the tops and fruits to develop satisfactorily late in the summer. In order to increase the yield it became necessary to learn how to manage the crop so that the earliest fruit could be secured and the late fruit developed satisfactorily. In addition, many other problems relating to various phases of the culture arose, and for more than 10 years the Ohio Station has been studying them. A method has now been established by which it is possible for growers to more than double former yields and maintain excellent quality throughout the season. Many experiments had to be made on the influence of light, heat, moisture, ventilation, fertilization, soils, varieties, and cultural practices so that a workable plan could be made which would guide greenhouse men in their management program. This program has progressed so far now that a set of recommendations can be made, and it is the purpose of the author to present them in a plan which may be used as a guide to growers.

## **VARIETIES**

Globe is still the leading greenhouse tomato variety in Ohio. Probably more than 75 per cent of the acreage is in this variety. Marhio is used to a certain extent. It is the heaviest yielding variety yet tried, but it has been limited more to the fall crop. The newest variety to be tried is Globelle. This new variety developed by the Ohio Station is resistant to *Cladosporium* leaf spot. It, too, may be used more as a fall variety. These varieties are pink in color, which is desired by most Ohio growers. In the southern half of the State where some red varieties are raised, Michigan State Forcing and Marglobe are preferred.

## **TIME OF SOWING SEED**

It has been demonstrated experimentally that the earlier the seed for the spring tomato crop is sown the larger the yield may be expected to be. The practice now is to sow the seed in raised benches or in flats the last week in November or early in December. The time usually required to raise plants sufficiently large to transplant well under winter conditions is about 7 or 8 weeks. When later crops are desired the seed sowing is delayed accordingly.

## **PLANT GROWING**

It usually takes about a week for the seed to germinate and the seedlings to get large enough to prick out. In order to save space, many growers set the seedlings 2 by 2 inches in raised benches or flats where they are left for about

2 weeks. At this time they are again shifted. When the plants are set directly into 4-inch pots they do better than when transplanted to raised benches at 4 by 4-inch distances and then dug up when finally set into the growing beds. The general trend now is to grow the plants in 4-inch pots after the first transplanting.

A recent modification of the pot method is to fill the pots with soil and plant two or three good seeds in them. This has the disadvantage of requiring much more room for starting the plants, but has the obvious advantages of omitting the transplanting and lessening the danger of spreading diseases by handling. Much stockier plants are frequently secured by this method and the growing period is also shortened by several days.

Further experiments with the use of electric lights on the young seedlings show that there may be considerable benefit if the usual environmental conditions are controlled. High night temperatures and soils high in available nitrogen and moisture may quickly undo the good that the additional light builds up. The temperature at night in all cases should be held around 60 to 62° F. to conserve the carbohydrates built up by the light during the day. The moisture supply should be regulated so that just enough is applied from day to day to provide for slow but continuous growth.

Soils for plant growing should be well supplied with phosphates and potash but should be low in quickly available nitrogen. Since it is usually necessary to use sterilized soil in raising young tomato plants, the soil should also be relatively low in organic matter, as the sterilization process liberates considerable amounts of nitrogen which may produce a vegetative plant that will not set fruit well when placed in the greenhouse.

## SOILS

Greenhouse soils vary widely. Experiments indicate that there is little difference in the crop-producing power of the different types when they are properly managed. Very nearly the same weights of marketable tomatoes have been obtained at Wooster from plants growing in beds filled respectively with beach ridge sand, Wooster silt loam, silty clay loam, and heavy silt loam developed from gray shale. The latter soils are very heavy and difficult to manage ordinarily, but when they are kept loose with fairly coarse organic matter and then managed as a more open type of soil, just as large crops can be grown. Light sandy or gravelly soils modified with well-rotted organic matter and judiciously watered and fertilized also produce large crops. When all things are considered, a naturally well-drained silty clay loam seems to provide as good facilities for greenhouse tomatoes as any soil.

It has been found advisable from the standpoint of sterilization effects, as well as the early growth of the succeeding crop, whether the soil is sterilized or not, to allow the old crop to remain in place long enough to remove the readily available nitrogen and moisture from the soil before pulling out the plants. Dry soils which have been pulverized by tillage tools sterilize much more quickly and thoroughly than moist ones or those that are left compact. When the quickly available nitrogen has all been used, there is less danger of causing a vegetative type of growth in the next crop with loss of early blossoms and increased danger of excessive amounts of blossom-end rot after the young fruits have started to develop.

### SOIL STERILIZATION

As nematodes, soil insects, and diseases accumulate it becomes necessary to destroy them. The most satisfactory method is by steam sterilization. Temperatures of 140° F. for a few hours will effectively kill nematodes and insects which live in the soil. For certain plant diseases, such as *Fusarium* wilt of tomato, the temperature should be maintained at 180° F. or higher for 6 to 8 hours to ensure that all lumps and wet spots will be properly heated. Manure, in most cases, should be applied in advance of the fall crop. In any case it should be applied and plowed down in advance of sterilization if there is any doubt about its freedom from harmful insect and disease pests. A single sterilization would, then, destroy any pests that might be contained in both soil and manure.

Prolonged sterilization tends to kill all bacteria and all fungi except those types which form heat-resisting spores. After the soil cools sufficiently the spores germinate and these fungi grow rapidly. They attack the organic matter and decompose it quickly. The protein is broken down and ammonia is given off as a by-product. The ammonia presumably unites in the soil solution with carbon dioxide to form ammonium carbonate, which is very injurious to the roots of many plants. If the sterilization is done preceding the fall crop as is recommended, the soil will have recovered its normal kinds of bacteria and fungi and will be in good condition for the spring crop. If it becomes necessary to sterilize it again in the winter, there is danger that so much nitrogen will be released that there will be trouble in setting the early fruit.

### SOIL PREPARATION

It is important that the plant bed be prepared deeply and thoroughly. All lumps should be well pulverized. In small areas the soil will still have to be turned with a spade or fork. When large areas are to be prepared the soil should be plowed with either horse or tractor power. The new rotary tillers do an excellent job in the greenhouse so long as there is considerable organic matter in the soil. If the organic matter is low and the soil heavy there is danger that the soil will settle into a solid mass after it has become thoroughly wet. This packing forces out the air and smothers most of the fine roots, and the plants will not grow well. When the soil is plowed, it will have to be disked, smoothed, and packed to be put in final condition to plant. The rotary tillers do all the operations at one time except packing and save considerable labor.

### FERTILIZERS AND MANURES

Plants in general depend on the kinds and quantities of mineral nutrients in the soil for their vigor and productiveness, and the tomato is no exception. In fact, by supplementing the supply of the soil yields may be greatly increased and the harvesting period prolonged indefinitely if the plants can be kept free from disease and insect attacks.

As a result of more than 10 years of observation and study of fertilizer quantities for greenhouse tomatoes on northeastern Ohio soils, it is found that much more can be profitably used than was formerly supposed. The present recommendations are: superphosphate, 1000 to 1500 pounds per acre, and

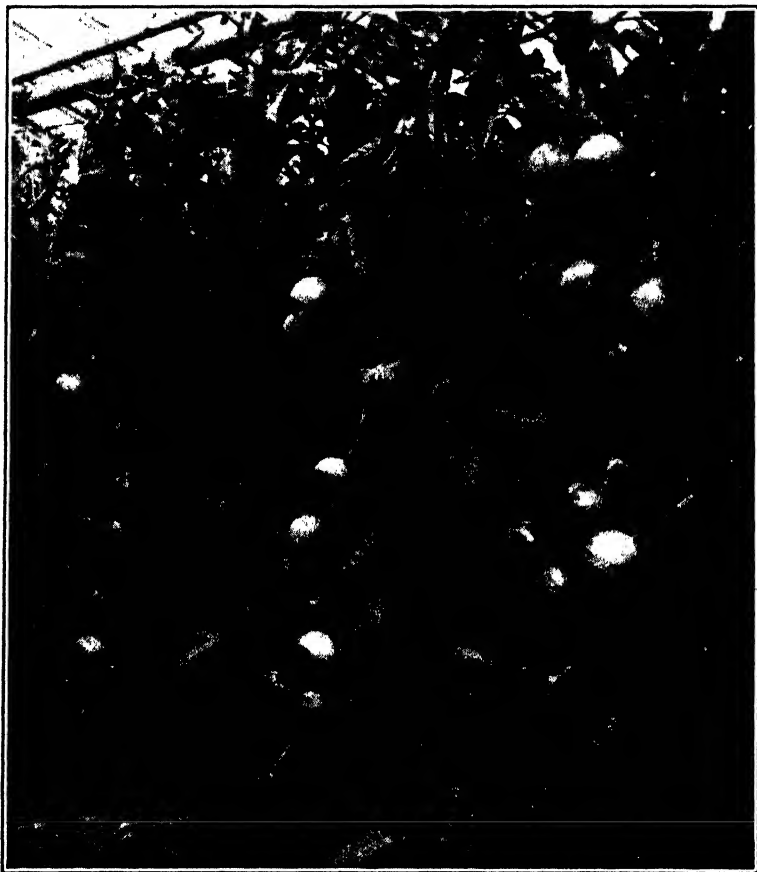
muriate of potash, 750 to 1000 pounds per acre. They may be mixed or left separate and applied broadcast before or after the ground has been sterilized, as the grower prefers. The sterilization does not materially affect their availability, but thorough mixing with soil to plow depth is important so that they are so well distributed that they will not injure the plant roots. No nitrogen is applied at this time. It is withheld until after three clusters of blossoms have set fruit and the fruits on the bottom clusters are about half grown. Nitrogen is then applied to promote large size in the fruits and continued growth in the plants. It has been found that nitrogen may be applied either as ammonia or nitrate. If the soil is near the neutral point ammonium salts are satisfactory if there is also a fairly large amount of soluble calcium present. If the soil is moderately acid in reaction or if the soluble calcium is low, then nitrates seem to give a better response. Ammonia is used as ammonium sulfate or ammonium phosphate. Both fertilizers are used at the rate of 200 pounds per acre each application, and the applications are repeated every 10 days or 2 weeks during the crop.

The nitrates which are now being used are sodium nitrate, calcium nitrate, and potassium nitrate. They are applied at the rate of 250 pounds per acre every 10 days or 2 weeks during the crop. Sodium nitrate is not recommended on heavy soils for continuous use over a long period of time, as it tends to destroy the granular condition of the soil and makes it difficult to manage. Calcium nitrate and potassium nitrate are proving to be very fine fertilizers, as the plants absorb all the salts and leave no accumulation in the soil to cause trouble. The following program of fertilization is now being recommended for northern Ohio.

- A. When the soil is prepared before planting:
  - 1000 to 1500 pounds per acre of superphosphate
  - 750 to 1000 pounds per acre of muriate of potash
- B. When fruit has set:
  - First application, potassium nitrate, 250 pounds per acre
  - Then two applications of calcium nitrate, 250 pounds per acre each
  - One application of potassium nitrate, 250 pounds per acre
  - Two or three applications of calcium nitrate, 250 pounds per acre each
  - One application of potassium nitrate, 250 pounds per acre

The nitrogen applications are spread broadcast between the rows and watered in with a regular irrigation. This amount of water is desired to dissolve all the fertilizer and carry it into the soil far enough so that the roots will not be damaged. There is no danger of damage when this amount of water is used, for more than 1000 pounds per acre of each of these salts have been applied in the Station greenhouses without burning the roots. Such excessive amounts are not recommended, however, for they tend to interfere with the absorption of water and retard plant growth besides being wasteful of fertilizer. Calcium and potassium nitrates may be mixed and applied at the same time. The mixture should be about one-third potassium nitrate and two-thirds calcium nitrate and used at the rate of 250 pounds per acre. The potash level in the soil should be high at all times, for tomato plants remove as much or more potassium from the soil than nitrogen. Relatively large amounts of potash are

removed in the fruit and so cannot be removed to new plant parts for re-use as may be done from the old leaves. When the potash level in the soil becomes low the tomatoes become flat sided, angular, and hollow and often ripen unevenly. They are also light in weight and of poor quality.



**Fig. 1.—By this method of culture it is possible to grow large heavy tomatoes on 12 to 14 clusters or more.**

These fruits are on the upper parts of plants which have grown up over the wire and nearly reach the ground again.

Manures, as was said in an earlier paragraph, should be applied in advance of the fall crop, so that the quickly available nitrogen will be used up. The quantities to be used are about 50 to 60 tons per acre. If a mulch was used the remains of it are worked into the soil for the spring crop. In case the soil is very heavy or the organic matter is very low for some reason, it may become necessary to add manure for the spring crop. In this event the usual amount is recommended, but unusual care will then have to be taken to control temperatures and moisture to prevent excessive growth and loss of fruit. In addition

to their fertilizer value, manures are valuable also as sources of carbon dioxide and as a medium for bacterial and fungous growth. They also improve the physical condition of many soils by loosening the heavy types so that the roots will be able to spread more easily.

**Minor elements.**—In Ohio, especially in the northern part, there frequently arises a need for two or three of the so-called minor elements. This condition follows excessive liming or steam sterilization. Magnesium, manganese, and iron have been the only minerals lacking so far, and when needed, magnesium and manganese are supplied as sulfates at the rate of 50 to 75 pounds weekly for 4 or 5 weeks, or as a single application of 200 to 250 pounds per acre. Iron as ferrous sulfate is applied at the rate of 125 pounds per acre at a single application, or in several applications of 25 or 30 pounds each when needed to relieve the trouble. Copper, zinc, and boron have not as yet shown any increased growth under Ohio conditions and are, therefore, not recommended for general use.

### TRANSPLANTING AND EARLY CARE

For the spring crop, setting the plants in the greenhouses begins about the middle of January and extends over into early February. Well-grown potted plants are to be preferred, as there is no shock at planting time and growth proceeds uninterruptedly. Good crops have been secured by dibbled plants, but as a rule the growth is irregular and generally the results are not so good as when potted plants are used. In general, the plants are set somewhat deeper than they grew in the pots. The unbroken ball of soil surrounding the roots is put into a hole sufficiently deep to take at least  $\frac{1}{2}$  inch of soil to cover it.

**Planting distances.**—The best planting distances cannot be determined easily. Locations, soils, and other factors vary too widely to make a positive statement possible. It is becoming recognized, however, that the plants have been set too closely in the past. As a result of experiments at the Station and in cooperating greenhouses it has been found that the rows should be about  $3\frac{1}{2}$  feet apart as an average and the plants about 16 to 18 inches apart in the rows, or that each plant should have about 5 square feet of ground. At the Experiment Station plants set 20 inches apart in the rows have usually produced heavier yields than in commercial houses, because the fruits have grown so much larger.

**Early care.**—As soon as the plants have been set, they should be watered. It has been found that the amount applied at this time should be kept low. When tomato plants are grown with small amounts of water they arrive at blooming time in more nearly the fruitful condition than when grown with much more water. During the short, cloudy days of winter and early spring, there is not enough light available to make enough carbohydrate material so that proper buds can be formed. Just enough water should be applied to provide for a slow growth. This would be provided with an irrigation of about  $\frac{1}{2}$  to  $\frac{3}{4}$  inch per week for the first few weeks.

The temperatures should be kept relatively low at night and on cloudy days in winter. At night, they should be held at 60 to 62° F. and on cloudy days at 65° F. Less carbohydrates are lost at these temperatures than at higher ones. The combination of relatively dry soils and cool temperatures tends to conserve carbohydrates and produce more fruitful buds. Nitrates in the soil also tend

to produce a rapidly growing plant which will not set fruit easily. The fall fertilizing program should be planned so that most of the nitrate nitrogen will be used up before the fall crop is removed. A soil poor in nitrates (less than 20 pounds per acre) is desired. Such a soil, in combination with the low temperatures and relatively dry soil, provides the best conditions for producing fruitful plants early in the spring season.

### PRUNING AND TRAINING

Tomato plants are nearly always trained to single stems and supported on strings which are tied to wires suspended over the rows. From a commercial grower's standpoint it makes no particular difference whether the plants are tied to the strings or whether they are wound around them. The latter method is more rapid and so, less expensive. It is the one commonly used.

Pruning amounts to the removal of side shoots on the plants and occasional leaves that have become broken or have turned yellow from shade or disease. Sometimes branches grow out of the central leader of a few clusters. These should be pruned off at the end of the cluster. Whenever single leaves appear at the ends of the clusters they may be left on, for the sugars which they produce aid in developing the fruit on those clusters. No active green leaves should be pruned from tomato plants at any time. This is especially true early in the season. Since the leaves build up the carbohydrates so that the buds may be properly developed, it follows that their removal may prevent the proper development of the buds. That this is the case has been shown at the Ohio Station by direct experiment. From 25 to 30 per cent loss has been found when green leaves were removed from the plants too soon.

If the tops of the tomato plants are removed about 5 or 6 weeks before the end of the season, the young fruits will grow faster and a larger percentage of them will reach maturity than if the plants are left to continue growth.

### MULCHING

The effects of organic matter used for mulching vary considerably. The strawy types tend to use up considerable nitrogen during the decomposition of the straw. Although locking up the nitrogen is only a temporary process, it is long enough to produce acute nitrogen deficiencies under greenhouse conditions. It usually compels the use of somewhat more nitrogen than otherwise would be necessary to guard against loss in size and numbers of fruits.

Clover chaff, low-grade alfalfa hay, and soybean straw make satisfactory mulches. They contain enough nitrogen to decay themselves without taking much from the soil.

The function of mulches seems to be largely that of a soil cover which improves the working conditions for the laborers and delays the runoff of water from the high places into the low spots. Mulches furnish also a source of carbon dioxide, and when they are finally worked into the soil minerals and humus are liberated as the process of decomposition progresses. Mulches are unnecessary to greenhouse production. Tomato plants will yield as many tomatoes and in many cases larger ones without mulches. They do improve working conditions, however, and, by keeping the surface of the soil moist, provide conditions in the upper layers of soil suitable for the growth of feeding roots which may make it possible to make somewhat quicker use of supplementary applications of fertilizers.

## WATERING

In the early spring watering the tomato crop is an exacting operation. In an earlier paragraph the watering of young tomato plants for a few weeks after the plants were set in the growing houses was described. As the days lengthen and more sunlight is available, the plants build up more carbohydrates. Fruits set more freely and begin to grow more rapidly. In March the quantity of water should be increased to  $\frac{3}{4}$  to 1 inch each week. In April  $1\frac{1}{4}$  to  $1\frac{1}{2}$  inches a week will be needed to produce large fruits, maintain good active plants, and prevent blossom-end rot. The long days of summer with their high temperatures and generally low humidities create a demand for still more water. Frequently  $1\frac{1}{2}$  to  $2\frac{1}{2}$  inches of water a week are necessary to obtain the best crop. The high levels of soil fertility with the abundance of water that can safely be used are capable of producing very large yields. Syringing water over the tops of the plants during the middle of the day helps to reduce the temperature within the houses, raises the humidity so that there is less danger of blossom-end rot of the fruits, and guards against loss of blossoms in the tops of the plants. The extra syringing will not cause leaf mold (*Cladosporium*) to start if time is given for the plants to dry off before night. If tomatoes are grown too dry the fruits are small and very solid. Under excessively dry conditions the fruits are so dry that the rind feels granular to the tongue and the tomato is acid to the taste.

## HEATING AND VENTILATING

**Heating.**—Tomato plants grow most satisfactorily under winter conditions at 60 to 62° F. at night and about 65° F. on cold, cloudy days. On days when the sun shines and the temperature within the greenhouse rises, air should be admitted through the ventilators to keep the temperature between 70 and 75° F. These daytime temperatures are the best ones for the tomato, and an effort should be made to keep the temperature of the houses within this range as much as possible. Carbohydrates are built up rapidly and are conserved for use better than at higher temperatures. When the temperature runs to 85° F. or more the carbohydrates are destroyed by respiration so fast that not much is left in reserve for growth. This may be one of the contributing causes for loss of blossoms during the long days of summer when they ought to be setting fruit rapidly. Another factor which often acts with high temperatures to cause loss of blossoms is a low nitrogen supply in the soil. The low nitrogen supply causes poor growth, small leaves, and yellowish color. These tend to limit the amount of carbohydrates formed, and high temperatures tend to destroy them so rapidly that no reserves are built up. Since it requires reserve carbohydrates to form good buds, lack of them causes the buds to drop. Night firing is often necessary even during the early summer to keep the humidity down and help prevent the development of leaf mold.

**Ventilating.**—Ventilation is necessary to provide a change of air. Carbon dioxide is used up by the growing plants, and fresh supplies have to be admitted through the ventilators. Plants give off moisture which raises the humidity. When the relative humidity rises to 90 per cent of saturation or higher, conditions are favorable for starting leaf mold. Ventilation provides a means of escape for much of the moisture vapor and lowers the humidity. Heating the air dries it still more, and the two operations together have been the best means of controlling this disease. Ventilation is an operation which changes the air, cools the houses, and lowers the humidity.

### POLLINATION AND FRUIT SETTING

Pollination must be done by hand methods in greenhouses. In early spring it is necessary to use extreme care, for the pollen is not formed in such large quantities and does not flow as easily as it does later. In order to get the pollen out it is necessary to tap each cluster five or six times with a light stick. It has been found best at the Station to tap each cluster every day as long as there are any open blossoms. The pollen is good for several days; so there are several applications of pollen on each blossom. This makes for large, well-shaped fruit if other conditions are satisfactory. Tapping the plants or strings with a rubber hose or heavier stick and pounding the wires are other methods often used when the plants are taller. They are not as satisfactory as tapping the individual clusters, for more small and imperfect fruits are formed.

### YIELDS

By using the methods described, very large yields have been secured in the Station greenhouses. The yield varies somewhat with the variety. The Globe variety has been yielding more than 15 pounds per plant for the early crop during the past 2 or 3 years. Under the same conditions Marhio has been yielding approximately 18 pounds per plant. These yields calculated in baskets per acre would be 13,700 baskets of Globe and 16,335 baskets of Marhio per acre. Picking begins in the Station greenhouses about the middle of April and ends about the middle of July. Marhio is a week to 10 days earlier than Globe when planted under similar conditions in the greenhouse and will continue to produce heavier fruits throughout the season than Globe. All other varieties which have been tried, whether red or pink, have yielded less in the Station greenhouses than Globe and Marhio up to the present. Globe has been the favorite in the past, largely because it ships better than most other varieties. Several other varieties are being improved so rapidly, however, that it may be superseded in the near future.

# **SHELLING PERCENTAGE AND TEST WEIGHT PER BUSHEL IN OHIO CORN HYBRIDS**

**G. H. STRINGFIELD<sup>1</sup>**

If 100 pounds of ear corn contain 80 pounds of grain and 20 pounds of cobs, the shelling percentage of that particular lot is 80. Shelling percentage is seldom much below 80 or above 85. Williams and Welton of the Ohio Experiment Station reported on 6 years' work in 1915 and showed that seed ears having high shelling percentages were no more likely to produce high yields than those with low shelling percentages. T. A. Kiesselbach, working under considerably different climatic conditions in Nebraska, and others have corroborated the Ohio findings. In developing new strains of corn, shelling percentage must then take a minor place in comparison with such major items as high acre yield and resistance to lodging, disease, insects, cold, heat, drouth, and other destructive environmental factors. Modern corn breeders seem to have selected slightly toward a lower shelling percentage. This is probably a result of eliminating most of the high shelling inbred lines because of their higher incidence of mold.

Even a slight change in shelling percentage, however, gives rise to a problem in corn marketing. It is difficult at best to arrive at a fair estimate of the actual feed value of ear corn. Differences in moisture content lead to more error than differences in shelling percentage, but without actual determinations both are unknown quantities. A corn buyer who has set his price for ear corn on a basis of shelling percentages as he has known them in past experience may be excused for being concerned when offered a load of a corn hybrid new to his experience and appearing to have shallow grain tagging it as low in shelling percentage. He does not care to pay a corn price for a load of cobs. On the other hand, neither does the seller wish to take an exaggerated cut if his ear corn contains practically the same amount of grain as that of the purchaser's past experience.

The data in Table 1, although not proposed as final nor as showing the differences in precisely accurate terms, should be helpful to those concerned about shelling percentages in corn hybrids. The data were taken from the official field performance plots in 1936 and 1937. Each strain (hybrid or variety) was grown in five randomly distributed plots for one test. Each plot was sampled by harvesting alternate hills, without any selection for good or bad ears, until enough ears were had to fill a 25-pound onion bag. Five such samples totaling approximately 60 pounds were taken for each strain. The samples were dried to 15 per cent or less of moisture and shelled air-dry. The appropriate weights were taken and the percentages computed.

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<sup>1</sup>In cooperation with the Division of Cereal Crops and Diseases, Bureau of Plant Industry, United States Department of Agriculture.

TABLE 1.—Shelling Comparison, Hybrids versus Open-pollinated Varieties, 1936 and 1937

	Ohio M15	Ohio K23	Ohio K24	Iowa 931	Ohio W17	Iowa 939	Pioneer 311A	Ill. 384	Ill. 172	U.S. 65	U.S. 52	Ind. 614	U.S. 44	Ohio L31
Shelling percentage														
Hybrid.....	86.01	83.66	85.62	83.67	83.97	84.27		82.84	83.84	83.44	83.22	81.52	83.21	81.61
Cook variety.....	86.7	86.3	87.3	86.3	86.3	86.3		83.7	85.7	85.7	86.8	84.3	86.8	86.8
Hybrid.....	85.61	83.35	85.81	82.66	84.29	84.26	84.11	82.84	83.86	83.44	83.47	82.97	83.68	82.78
Woodburn variety.....	86.9	86.1	88.2	86.5	86.5	86.5	87.0	86.0	85.3	86.0	86.1	85.6	85.7	85.4
Hybrid.....	85.61	83.76	85.62	82.77	84.27	84.37	84.11	82.84	83.86	83.44	83.38	82.44	83.24	81.74
Clarage variety.....	85.0	84.4	84.6	84.3	84.3	84.3	83.1	84.1	83.7	84.1	83.5	83.1	83.8	83.2
Hybrid.....	85.73	83.517	85.75	83.020	84.123	84.220	84.12	82.812	83.816	83.412	83.312	82.313	83.313	82.013
Three varieties.....	86.2	85.6	86.7	85.7	85.7	85.7	85.1	85.3	84.9	85.3	85.5	84.3	85.4	86.1
Grain weight per bushel of ears														
Hybrid.....	60.03	58.517	60.05	58.120	58.923	58.936	58.92	58.012	58.716	58.412	58.312	57.613	58.313	57.413
Three varieties.....	60.3	59.9	60.7	60.0	60.0	60.0	59.6	59.7	59.4	59.7	59.9	59.0	59.8	59.6

Each square in the table gives three items of information as follows:

Upper right corner    The number of comparisons in shelling percentage between the hybrid directly at the top of the table and the variety directly at the left

Center                      The average shelling percentage of the hybrid

Bottom                      The average shelling percentage of the variety

Example: In the second column of squares, Ohio K23 was compared with Cook variety in six tests. K23 averaged 83.6 shelling percentage, compared with an average of 86.3 for Cook. The next two squares below show similar comparisons with Woodburn and with Clarage. The fourth square gives a similar comparison of K23 with the average of the three varieties. The bottom square shows the pounds of grain in 70 pounds of ears, comparing K23 with the average of the three varieties.

Open-pollinated varieties are by no means all the same in shelling percentage, even under comparable growing conditions. Two of the varieties shown in the table, Woodburn and Cook, are representative of high shelling open-pollinated corn adapted to the western Ohio area where large quantities of corn are marketed as grain. The Clarage used was with one exception the Wooster strain, and it is probably slightly lower in shelling percentage than some of the later Clarage strains. It is not lower, however, than many other open pollinated farm strains.

The data emphasize a fact already well known to hybrid corn men, namely, that corn hybrids differ from each other as much as varieties do. In some respects they differ more. It is true, however, that at least most corn hybrids in present use in Ohio are a little lower in shelling percentage than such notably high shelling varieties as Woodburn. But how much lower? Depending on which hybrid it is and on differences in growing conditions, the hybrid may apparently be expected to have a lower shelling percentage by from 1 to 4 per cent, based on total ear weights. If the hybrid is compared with an open-pollinated variety like early Clarage, it would be expected to have as high a shelling percentage as the variety, or within about 1 per cent of it.

The bottom row of squares shows the grain weight in pounds expected from 70 pounds of ears for each hybrid compared with the average of the three varieties. The average value is 59.8 for the varieties and 58.6 for the hybrids. Assuming that cobs have no value, one would expect hybrid ear corn to be worth about 2 per cent less on the average than an equal weight of ears from an open-pollinated variety. This is a very generalized figure but it can be used as a point from which to estimate. It indicates that a slight adjustment for lower shelling percentage is reasonable in marketing most hybrids but that a cut of several cents a bushel is likely much out of line. With ear corn at 70 cents a bushel, a 2 per cent cut would be only 1.4 cents a bushel. None of the hybrids listed in the table would be expected to shell out less than 80 per cent grain if grown in their recommended areas and in good growth conditions.

These comparisons were largely north of the adapted area for Ohio L31, which is probably the explanation for its relatively low shelling percentage.

TABLE 2.—Comparison of Test Weights per Bushel, Hybrids versus Open-pollinated Varieties, 1937

	Ohio M15	Ohio K23	Iowa 931	Ohio W17	Iowa 939	Ill. 384	Ill. 172	U. S. 65	U. S. 52	Ind. 614	U. S. 44	Ohio L31
Hybrid..... Cook variety .....	56.61 55.4	55.74 56.4	55.84 56.4	56.34 56.4	55.54 56.4	55.41 56.7	55.53 56.7	57.43 56.7	56.22 56.7	55.32 57.3	57.01 57.9	55.61 57.9
Hybrid..... Woodburn variety.	58.01 56.9	55.85 56.2	56.14 56.0	57.56 56.5	55.44 56.0	55.02 55.1	55.53 55.7	57.43 55.7	57.34 56.6	56.44 57.0	57.83 57.4	56.73 57.4
Hybrid..... Clarage variety...	58.01 55.0	56.04 54.7	56.14 54.7	56.94 54.7	55.44 54.7	55.02 53.4	55.53 54.6	57.43 54.6	55.52 55.1	55.32 55.3	57.01 57.0	55.61 57.0
Hybrid..... Three varieties....	57.53 55.8	55.814 55.8	56.012 55.7	56.916 55.9	55.412 55.7	55.15 55.1	55.59 55.7	57.49 55.7	56.38 56.1	55.78 56.5	57.35 57.4	56.05 57.4

### TEST WEIGHT PER BUSHEL

Table 2, which is read in the same manner as Table 1, shows comparative data on the number of pounds per measured bushel of grain. U. S. 65 and possibly Ohio M15 and W17 run slightly heavier than the open-pollinated varieties. Indiana 614 and Ohio L31 are probably slightly lower because of being later than the competing varieties. No general statement that hybrids tend to run either higher or lower than open-pollinated varieties could be supported by these data.

## PALATABILITY OF SOYBEAN MEALS FOR DAIRY COWS

C. F. MONROE AND C. C. HAYDEN

In purchasing soybean meal the buyer frequently has a choice of three or four different kinds. Before deciding on any particular kind, he will be interested in knowing the relative feeding values of these meals and whether all are equally well relished by animals. Feeders have learned that palatability is an important consideration and that there are differences in tastes between the various classes of livestock. There is, however, a tendency to apply results obtained with one class of livestock to another. Because it is often assumed that cows would prefer the same kind of soybean meal as some other classes of livestock and because there was no information available regarding the preferences of cows, it was decided to conduct a palatability trial with different meals using dairy cows as the experimental animals.

The different kinds of soybean meal result from different methods of removing the fat from the beans. In the work described all three kinds of meal found on the market, hydraulic, expeller, and extracted, were compared. In addition to the regular extracted meal a recently introduced form of this kind was used. This new form of extracted meal is heat-treated, and is somewhat similar in appearance and flavor to the expeller and hydraulic meals. It is believed that the different meals used in this work were fairly representative of those on the market.

This work was concerned with palatability only; there was no attempt to determine feeding values.

### METHOD OF DETERMINING PALATABILITY

To determine the preference of cows for the different kinds of soybean meals some cows in the Station herd were allowed to eat, free-choice, from buckets containing either the straight supplements or grain mixtures containing these supplements. The buckets containing the feeds were placed in racks fastened to one side of the box stalls in which the cows were being kept (Fig. 1). Enough feed was placed in each bucket that a cow could get her entire grain allowance from one bucket without going to another. The order in which the buckets were placed in the racks was changed from day to day, so that the cows

would not become accustomed to eating from one position. In the actual feeding it was soon found that the time allowed for eating had to be limited, as the cows would keep on eating as long as there was feed before them. At the end of approximately 10 minutes, therefore, the lids on the racks were closed. As some cows were faster eaters than others there was some variation in the time allowance given individual animals.



Fig. 1.—Rack for buckets used in free-choice feeding

The arrangement of the buckets was varied from day to day.

This free-choice manner of feeding was followed for the afternoon feeding only. In the morning all cows were fed the same standard ration according to their needs; this was done partly to control the grain intake and partly to save the labor necessary for free-choice feeding.

Feed buckets were kept reasonably clean and refused feed was discarded at regular intervals so that fouling of feed would not affect the preferences. Fresh feed mixtures were made up at frequent intervals.

At the beginning of the experiment the straight supplements were placed in the buckets. This would appear to be the ideal method of determining the preferences for the different meals, but the physical condition of the meal may unduly affect the palatability in such cases. Probably the greatest objection to this method is that in practical feeding such a system is almost never used. This method was changed, therefore, and after the first trial the meals were mixed with the common feeds to form an 18 per cent total protein grain ration of which approximately one-fifth was one of the different kinds of meal. The formula was: ground corn, 350 pounds; oats, 350 pounds; wheat bran, 100 pounds; one of the soybean meals, 200 pounds; and salt, 10 pounds. The same formula was used throughout the work, and the resulting grain mixtures contained from 17.6 to 18 per cent of total protein, depending on the variety of meal used.

When the straight supplements were offered, 3 pounds were placed in each bucket. When the grain mixtures were used, the amount was generally 4 pounds, although at first it was 5 pounds. The unavoidable irregularities in

this method were adjusted in the morning feeding, when the grain was weighed out to each cow. The cows soon became accustomed to this manner of eating, and in only a few cases was there any trouble from overeating. This trouble occurred when the period allowed for eating was too long.

## RESULTS

The data divide into four divisions, which represent four different trials. The results of these trials are shown in Tables 1 to 4 by weights of feed consumption and also by the number of days each feed received the preference.

### TRIAL 1

In Table 1 the results are given for the comparison between the straight supplements.

**TABLE 1.—Consumption of Soybean Meals**  
Fed free-choice, without mixing with other grains

Cow No.	Days fed	Total amount of each feed offered	Amounts of supplements eaten			Days of preference shown for—			
			Expeller	Hydraulic	Extracted	Expeller	Hydraulic	Extracted	Ties
		<i>Lb.</i>	<i>Lb.</i>	<i>Lb.</i>	<i>Lb.</i>				
419 J.....	27	81	41.1	19.1	0.8	20	6	0	1
421 J.....	10	30	14.9	7.8	6.4	5	2	2	1
457 J.....	27	81	61.8	14.5	22.0	26	0	0	1
512 H.....	27	81	35.1	25.4	21.5	14	4	6	3
Total...	91	273	152.9	66.8	50.7	65	12	8	6

All four cows ate more of the expeller meal than of either the hydraulic or the extracted meal. The days of preference also favored the expeller meal. The hydraulic meal was second in order, and the extracted meal last. Regardless of the marked preference for the expeller meal, the cows did not clean up entirely their daily allowance of this meal and ate some of the other meals. In fact, two of the four cows could have eaten all their grain from one bucket if they had been so inclined. The third cow could have done this except for 1 pound. The fourth cow overate her quota but nevertheless did considerable volunteer eating outside her first preference. All this indicates that there was not a strong dislike for the meals of second and third preference. The very fine texture of the extracted meal may have prevented the cows from taking more of it, for they had difficulty in eating this meal.

### TRIAL 2

The supplements were next offered in grain mixtures similar to those used in practical feeding. The results with the same four cows plus an additional cow are shown in Table 2.

**TABLE 2.—Grain Consumption**  
Supplements fed free-choice in grain mixtures. Short trial

Cow No.	Days fed	Total amount of each feed offered	Amounts of mixtures eaten			Days of preference shown for—			
			Expeller	Hy-draulic	Ex-tracted	Expeller	Hy-draulic	Ex-tracted	Ties
		<i>Lb.</i>	<i>Lb.</i>	<i>Lb.</i>	<i>Lb.</i>				
423.....	57	228	77.4	66.1	71.4	16	19	22	0
457.....	28	140	66.0	84.6	65.7	7	15	5	1
512.....	44	220	100.3	105.9	95.5	13	17	11	3
421.....	44	220	148.8	148.9	126.9	19	14	5	6
419.....	44	220	88.7	90.4	95.3	11	14	17	2
Total....	217	1028	481.2	495.9	454.8	66	79	60	12

The data for total consumption indicate that the palatabilities of these grain mixtures were about equal. The hydraulic led the expeller by a slight margin, and the extracted was not far behind. The data for days of preference are similar to those for the weights eaten. However, the cows were not all in agreement in their tastes. One cow preferred the expeller; two preferred the hydraulic; and one, the extracted; whereas the fifth cow ate practically equal amounts of hydraulic and expeller mixtures. In no case were the differences great; this indicates that there was no decided preference. It is interesting to note that cow 419, which hardly touched the extracted meal fed as a straight supplement, preferred the mixture containing this meal. Also, although cow 457 ate the least of the hydraulic meal fed straight, she preferred the mixture in which it was contained. The four cows in trial 1 which had shown preference for the expeller meal switched to one of the other two meals when fed with mixtures. The conditions influencing the palatability of the straight supplements were evidently changed or nullified when these supplements were combined with other grains in a practical feed mixture.

### TRIAL 3

The same mixtures were used with four other cows, and the trial was continued for a longer time. The data for this trial are shown in Table 3.

**TABLE 3.—Grain Consumption**  
Supplements fed free-choice in grain mixtures. Long trial

Cow No.	Days fed	Total amount of each feed offered	Amounts of mixtures eaten			Days of preference shown for—			
			Expeller	Hy-draulic	Ex-tracted	Expeller	Hy-draulic	Ex-tracted	Ties
		<i>Lb.</i>	<i>Lb.</i>	<i>Lb.</i>	<i>Lb.</i>				
373.....	179	716	319.9	187.8	348.6	40	27	101	11
386.....	170	680	56.6	68.0	276.9	23	24	123	0
465.....	128	512	291.5	266.2	292.6	42	27	46	13
435.....	83	332	181.6	165.2	151.3	33	30	20	0
Total...	560	2240	849.6	687.2	1069.4	138	108	290	24

The total figures indicate a change in preference to the extracted meal; expeller meal is second; and hydraulic, last. The days of preference follow in the same order. Two of the cows preferred the extracted meal mixture; one the expeller; and the fourth cow ate practically the same amounts of both expeller and extracted mixtures. Cow 386, a rather "picky" eater, showed a marked preference for the extracted mixture which unduly influenced the total consumption. Both this cow and cow 373, which also showed a preference for the extracted meal, were on test almost 6 months. They were not showing a tendency to change their preference toward the end of this period.

#### TRIAL 4

A new form of extracted meal which had been heat-processed was substituted for the hydraulic meal. The results of this trial are shown in Table 4.

TABLE 4.—Grain Consumption  
Supplements fed free-choice in grain mixtures. Heat-treated  
extracted meal substituted for hydraulic meal

Cow No.	Days fed	Total amount of each feed offered	Amounts of mixtures eaten			Days of preference shown for—			
			Expeller	Heated ex-tracted	Ex-tracted	Expeller	Heated ex-tracted	Ex-tracted	Ties
		<i>Lb.</i>	<i>Lb.</i>	<i>Lb.</i>	<i>Lb.</i>				
373.....	72	288.0	113.6	44.5	179.1	19	5	47	1
398.....	62	248.0	125.0	40.6	146.7	19	2	37	4
386.....	72	288.0	64.9	1.0	173.5	1	0	71	0
465.....	72	288.0	129.2	35.0	126.8	36	3	30	3
Total....	278	1112.0	432.7	121.1	626.1	75	10	185	8

Three of the four cows used in trial 3 also took part in this trial. The total figures, both for amounts eaten and days of preference, are in the following order: extracted, expeller, and extracted-heated. Three of the four cows showed a preference for the extracted meal. Two of these were decided preferences. One cow preferred the expeller meal.

After the completion of free-choice feeding the grain mixture containing the extracted-heated meal was fed as the entire grain ration to the same group of cows, to see if the lack of preference shown for this mixture in the free-choice feeding would also be indicated when the animals had no other grain. They ate this mixture readily.<sup>1</sup> The largest amount fed to any one cow was 12 pounds per day. The same test was conducted with these cows and the expeller meal mixture, with the same results. Although the test was not conducted with a mixture containing hydraulic meal, this meal has been fed at the Station with entire satisfaction.

This work indicates that the palatability of practical grain mixtures is little, if any, affected by the kind of soybean meal employed. With one exception there were no outstanding likes or dislikes shown for any particular mixture. This exception was in trial 4, where there appeared to be a dislike for the mixture containing the extracted-heated meal. These results, however, should be interpreted on the basis of preferences. A lack of preference does not necessarily mean that a feed is distasteful but simply that others are preferred to it for eating first. In this work the time allowed the cows to eat was limited.

<sup>1</sup>Included in the test was cow 386, which ate almost none of the extracted-heated meal mixture on free-choice feeding.

When such feeds are fed alone they may be sufficiently palatable to be satisfactory. This proved to be true with the mixture containing the extracted-heated meal, which was last in the order of preference in free-choice eating.

A rather surprising result of this work was the high degree of palatability shown for the mixture containing the extracted meal. Even after long-continued feeding the cows continued to show a marked fondness for this mixture. This was surprising, as these results were different from those obtained when the straight supplements were tested. The raw bean flavor and odor of extracted meal could still be detected in the mixture containing the extracted meal, and one could without great difficulty detect the difference between this mixture and the others by the odor. It would seem, therefore, that the raw bean taste and odor are not objectionable to cows. Incidentally, the experience gained in testing the palatability of this meal as a straight supplement and in feed mixtures indicates the necessity of using the mixtures if the results are to apply to practical feeding.

### SUMMARY

An attempt was made to determine the preference of cows for the different kinds of soybean meal by offering these meals free choice, both as straight supplements and in feed mixtures. The following kinds of meal were used: expeller, hydraulic, extracted, and extracted heat-treated. There were no marked differences in preference between the expeller, hydraulic, and extracted meals fed in grain mixtures. In the one trial in which the extracted heat-treated meal was used it ran a poor third to the extracted and expeller meals. When this mixture was fed as the only grain ration to the same cows it was eaten readily in satisfactory amounts.

## SEEDLESS PEACHES AS A RESULT OF FREEZING INJURY

LEON HAVIS

Recently Latimer and Rawlings (1) reported the development of seedless apples in New Hampshire resulting from a frost on May 21 and 22, 1936. Moreover, it is well known that many fruits may develop parthenocarpically, or without fertilization. The development of stone fruits, such as the peach, plum, and cherry following destruction of the seeds by frost is, however, very unusual. The purpose of this article is to record observations on the development of peaches following destruction of the seeds by frost on May 12, 1938.

It is not unusual for frost to occur as late as May 12 at Wooster, although the average date for the last killing frost is May 8 (2). The peach fruits were about 2 weeks more advanced than usual at the time of the frost in 1938. The

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1. Latimer, L. P. and C. O. Rawlings. 1938. The occurrence of seedless apples as a result of frost. *Proc. Amer. Soc. Hort. Sci.* 35: 111-115.

2. Alexander, W. H. and C. A. Patton. 1929. The climate of Ohio. *Ohio Agr. Exp. Sta. Bull.* 445.



Fig. 1.—Peach (left), plum (center), and sweet cherry (right) fruits at time of the severe frost on May 12, 1938

The photograph was taken in the afternoon of that day. Note darkened and shriveled condition of plums and one of the cherries.

trees were in blossom between April 15 and 20, and the fruits were 12 to 15 millimeters in length on May 12 when the frost or freezing occurred (Fig. 1). The temperature records at the Station orchards were taken by means of a thermograph located in an instrument shelter at a height of about 5 feet. The records showed that the temperature reached 32° F. at about 4:00 a. m. and that it remained below this point for about 4 hours, from 4:00 a. m. to 8:00 a. m. It was below 30° F. during 2 of these 4 hours, from 4:30 a. m. to 6:30 a. m. The minimum recorded was 29° F., but it was probably several degrees below that in the lower levels of the orchard.

### TREES AND METHODS USED

The experimental peach orchards at Wooster are composed of a large number of varieties varying considerably in age. The trees used principally in these studies were those between 3 and 5 years of age. The culture orchard, composed of the varieties South Haven and Elberta, was particularly valuable for these observations. The fruits from 90 South Haven and 92 Elberta trees planted in the spring of 1935 were used in this study. The South Haven is a relatively early variety and was ripe August 18; the Elbertas were harvested September 6, 1938. A few trees of about the same age on which there were many seedless fruits in the variety orchard were also observed closely and the fruits examined.

A large number of fruits were examined immediately after the freeze on May 12 (Fig. 1) and observations were made and recorded continuously throughout the season thereafter. All fruits of a given variety were harvested on the same date. Data were then taken with special emphasis on the relation of dead seeds to: (a) sizes of the peaches, (b) stage of ripeness, (c) number of split-pits, and (d) number of cracked fruits and severity of cracking. In addition to these data, embryos of several varieties of peaches were destroyed at several successive periods during the season beginning June 1; the method employed by Tukey (3) was used. Fruits on trees 10 to 12 years old which

3. Tukey, H. B. 1936. Development of cherry and peach fruits as affected by destruction of the embryo. *Bot. Gaz.* 98: 1: 1-24.

showed no freezing injury were used in this test to determine whether the fruits would develop after destruction of the embryo that early in the growth of the fruit.

## RESULTS

The severe frost or freeze of May 12, 1938, occurred about 3 weeks after the time of peach blossoming. Within 4 to 6 hours after the minimum temperatures the flesh of many of the young peaches appeared water-soaked and the seeds were dark brown to black. A few of the injured fruits fell from the trees immediately, but most of them remained on the trees for 10 to 15 days; then there was an extremely heavy drop. The flesh, as well as the seeds of most of the fruits which dropped from the young South Haven and Elberta trees in the culture orchard showed freezing injury. This drop, however, coincided very closely with the second drop which normally occurs with peaches about 5 weeks after bloom. Thus, it was impossible to determine just how many or what proportion of the fruits fell as a result of the frost alone. Evidently a great many fell as a direct result of the frost, since an average of only 10 to 12 fruits remained on the young South Haven and Elberta trees after this severe drop about 5 weeks after blossom. Furthermore, there was a fairly heavy drop from the trees 10 to 20 years of age in the variety orchard at that time, but only a small number showed freezing injury. Some thinning was necessary on most of these older trees, however, and a full crop was borne with very few seedless fruits.

The growth stages of the peach fruit have been described by Connors (4), Lilleland (5), and others. The three rather distinct stages of development are, briefly, the period of rapid increase in size (stage I), the stage of delayed increase (stage II), and the second period of rapid increase (stage III). Tukey (6) has described the relation between the development of the pericarp and the growth of the embryo in several varieties of peaches. During stage I, or for about 50 days following bloom, the embryo develops very slowly; whereas the nucellus and integuments of the seed, as well as the pericarp or flesh, develop rapidly. Thus, the freeze which destroyed many peach seeds in 1938 occurred about the middle of stage I, or while the embryo was microscopic and the seed was composed principally of nucellus and integuments.

The destruction of embryos by use of a dissecting needle at several periods through the season, beginning June 1, resulted in the dropping of all fruits in which the embryos were thus killed during stages I and II. These results are in line with those of Tukey (3), although he does not report destruction of the embryos earlier in the season than July 26 (stage II). During early June the fruits thus treated at the Ohio Station were in stage I of development.

The fruits in which the seeds had been destroyed by frost seemed to develop normally throughout the season of 1938 (Fig. 2). They developed through the three stages of growth according to the characteristics of the variety. If the peaches having dead seed developed very differently at any stage from those with live seed, it was not evident from general observations made every few days throughout the season. No chemical analyses nor detailed measurements of the fruit parts were made, however, during the growth period.

4. Connors, C. H. 1919. Growth of fruits of the peach. N. J. Agr. Exp. Sta. Forty-first An. Rep. P. 82.

5. Lilleland, O. V. 1933. Growth study of the peach fruit. Proc. Amer. Soc. Hort. Sci. 29: 8-12.

6. Tukey, H. B. 1934. Growth of the peach embryo in relation to growth of fruits, and season of ripening. Proc. Amer. Soc. Hort. Sci. 30: 209-218.

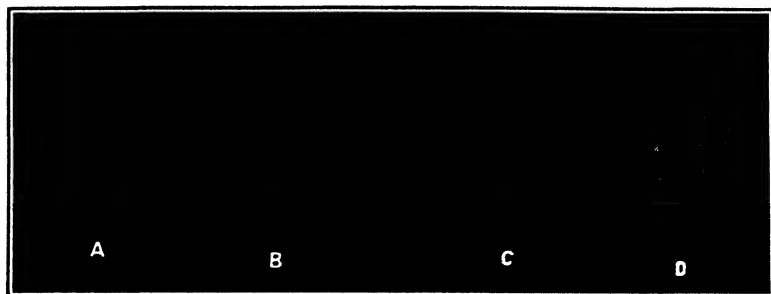


Fig. 2.—Peach fruits during the early part of the period of hardening of the stony pericarp (stage II)

Specimens A and B show no seed injury; C and D contain seed killed by frost.

Tukey (3) states that "Destruction of the embryo in the transition between stages II and III of development of the pericarp resulted in growth of the fruit at a rate similar to that of untreated fruit for a limited period, but ended with earlier ripening and failure to reach full size." He also found that "Destruction of the embryo in stage III of development of the pericarp resulted in increased growth rate and earlier ripening, and occasionally increased size over that attained by untreated fruits at maturity." The writer found that there was a tendency for the peaches in which the embryos were destroyed by frost to fail to reach the sizes attained by those showing no embryo destruction (Table 1). As shown in Table 1, however, there were a large number of peaches with dead seed that were included in the largest sizes. In South Haven more than 50 per cent of those over 2¾ inches contained dead seeds. As shown in Table 1, by far the larger number of fruits were classified as medium (1¾-2¾ inches) in size (Fig. 3). Most of the fruits of this group from the young trees given in Table 1 contained dead seed. Those classified as small (below 1¾ inches) were very largely of the 1¼- to 1½-inch sizes.

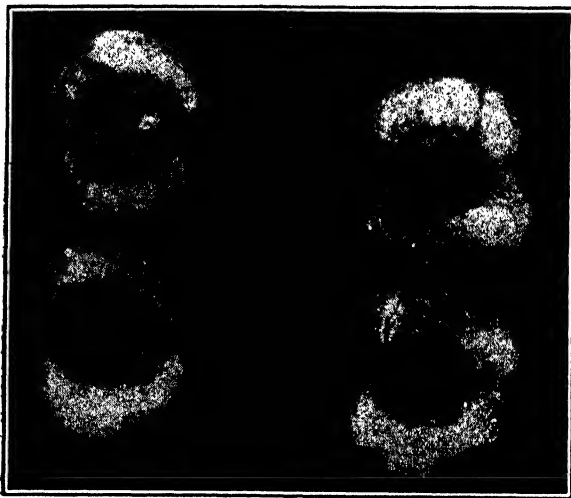
TABLE 1.—Destruction of Peach Seed by Frost in 1938

The numbers, sizes, and percentage of fruits of several peach varieties containing dead seed are given.

Variety	Date planted	Number and sizes of peaches examined*			Percentage of fruits of three sizes containing dead seeds*			
		Large	Medium	Small	Large	Medium	Small	Weighted average
Halehaven .....	1934		155			92.3		92.3
South Haven .....	1935	174	308	192	54.0	91.5	98.9	83.9
Goldeneast .....	1935	1	16	1	0.0	100.0	100.0	94.4
Downing .....	1934		39			94.8		94.8
Elberta .....	1935	100	714	254	16.2	76.0	88.3	73.3

\*Approximate sizes: large, 2¾ inches or over (average of 3 inches); medium, 1¾-2¾ inches; small, below 1¾ inches.

No difference could be determined between the time of ripening of the fruits containing destroyed seed and those in which the seeds were well developed. All fruits of a given variety were harvested on the same date so that this factor could be determined. The fruit studied ripened at the normal time with respect to the ripening dates of other varieties.



**Fig. 3.—Ripe peaches (variety Lockwood) showing: left, fruit containing uninjured seed; right, fruit in which seed was destroyed by frost on May 12. The arrow indicates position of small dead seed in uninjured specimen.**

No definite relationship was secured between the destruction of the seed by frost and the number of split-pits. There were, however, the most split-pits in the fruits from the same trees as those with dead seeds. Probably this was because both situations were associated largely with young trees bearing few fruits. Davis (7) found "a close relationship between the size or growth rate of fruits (peach) and occurrence of split-pits." It is not unusual to find many fruits with split-pits on trees bearing few fruits.

The flesh of a large number of the fruits borne on the young South Haven and Elberta trees showed severe cracking. Neither the number of cracked fruits nor the severity of cracking, however, seemed to be associated with frost-killed seeds.

Many peaches harvested in 1938 were malformed, evidently owing to freezing injury to the flesh. Some of these contained dead seed, but no definite external character was noted by which those with dead seed could be distinguished. As mentioned before and shown in Table 1, the larger peaches were more likely to contain fully developed seed than the fruit of the somewhat smaller sizes.

7. Davis, L. D. 1934. Size and growth relations of fruit in splitting of peach pits. *Proc. Amer. Soc. Hort. Sci.* 30: 195-200.

Little difference was noted in the endocarp or stone development of the fruits in which the seeds were destroyed by frost and the uninjured ones. The seed cavity was present in the mature fruit, even though the seed had been destroyed some time before the stone hardening period (stage II). The cavity was hardly perfect, however, in some cases, as may be noted from Figures 2 and 3.

Tukey (3) states that in answer to the question raised by him previously "as to whether embryo abortion is responsible for the accelerated growth of pericarp in early-ripening varieties of cherry and peach, or whether it is the rapid growth of the pericarp which brings about embryo abortion, these results indicate that the embryo is the controlling factor." He states further, however, that "It would seem that there are at least two factors in operation in this situation, the stage of development at which embryo destruction occurs and the characteristics of the variety." From the results obtained in Ohio in 1938 it seems that where few peaches are borne on young, vigorous trees embryo development may not be as important in the fruit growth as otherwise. The factor of "characteristics of the variety" was emphasized in these observations. The situation which prevailed in 1938 is doubtless very unusual, however, and its interpretation is not clearly understood.

## CHEMICAL CONSERVATION OF MANURE

C. J. SCHOLLENBERGER

Good mixed farm manure averages 10 pounds of nitrogen, 5 pounds of phosphoric acid, and 10 pounds of potash in a ton at 80 per cent moisture content. The nitrogen contributed by dung and straw is very slow acting; that from urine, half the total, changes quickly to ammonia, in which form its fertilizer value is great, but nearly all this nitrogen may be lost by heating during fermentation and exposure to air with freezing or drying before the manure can be incorporated into the soil. The phosphoric acid and potash of manure are not volatile; hence will not be lost if the manure is protected from leaching. Allowing half value for total nitrogen and full value for phosphoric acid and potash, at present retail prices for fertilizers (6.9 cents per pound for nitrogen, 5.9 cents for phosphoric acid, and 4.3 cents for potash) the value of these constituents in a ton of manure is about \$1.

It is possible to prevent the greater part of the usual loss of ammonia from manure by acidulation, for which purpose phosphoric acid seems best adapted, as it has direct fertilizer value. Mixing ordinary superphosphate with the manure has a somewhat similar effect in fixing ammonia. Tests at the Vermont Experiment Station have shown that from 1 ton of cow manure with 10 pounds of phosphorus pentoxide supplied as liquid phosphoric acid and superphosphate, the total losses of ammonia from drying were reduced to 49 and 66 per cent, respectively, as compared with a 93 per cent loss from untreated manure. Since it has been general experience that the use of an available phosphate fertilizer to supplement manure is highly profitable, mixing this material with the manure to take advantage of its nitrogen-conserving action seems a logical way of using it.

Unfortunately, for practical commercial reasons, the price per pound of phosphorus pentoxide in a crude liquid acid is nearly 10 cents, as compared with 6 cents in superphosphate, leaving a net charge of 4 cents per pound over the fertilizer value. Since the value of the nitrogen that may be lost from a ton of manure is only 35 cents, there would be no profit even if 10 pounds of phosphorus pentoxide as liquid phosphoric acid saved all of it. In the test of superphosphate previously mentioned, this treatment proved about two-thirds as effective in preservative action as the liquid phosphoric acid. The cost of treating a ton of manure with superphosphate at this rate would be 60 cents, and the saving in nitrogen to be expected might amount to 25 cents. This would be worth while if it were certain that the superphosphate retained its full fertilizer value after conserving the nitrogen, but this is by no means the case. In the first place, the preservative action of superphosphate necessarily entails the change of all the water-soluble phosphoric acid into insoluble tricalcium phosphate, with inevitable loss in value except on the more acid soils. Secondly, superphosphated manure must be applied broadcast, and it is well known that the most efficient use of superphosphate is in the hill or row, to minimize fixation by soil minerals and supply an abundance of available phosphoric acid to give the plants a good start. Under many circumstances, the loss in efficiency of the phosphoric acid from these and other factors might easily cancel the savings to be expected from conservation of manure nitrogen.

Superphosphate mixed with manure in the stall, 1 pound of 20 per cent goods for each cow daily, or at half the rate used in the test mentioned, might be expected to be more profitable in proportion to the investment, especially when the manure is to be applied to meadows and the like as a top-dressing, but the economy of such use generally is doubtful.

There seems to be no better rule for realizing the value of manure than the old one of moist, compact storage if necessary, with prevention of leaching and prompt covering with soil after spreading in calm, cool, moist weather. If acid peat moss is available for use as stable litter, its ability to absorb ammonia and limit fermentation will result in lower losses than are usual with straw, and this appears to be a more promising means for conserving nitrogen in manure than the addition of chemicals.

## DISTRIBUTION OF LATE-CROP OHIO POTATOES 1936 AND 1937

CHAS. W. HAUCK

A distinct advantage to the Ohio potato grower is his ability to find markets within a relatively small area. Ohio is deficient in the production of potatoes; that is, fewer potatoes are grown in Ohio than are consumed in Ohio.

The average annual consumption of potatoes in Ohio during the 5-year period 1933-1937 was estimated to be almost 20,000,000 bushels; whereas production within the State averaged only slightly more than 13,000,000 bushels annually. About 7,000,000 bushels, therefore, had to be shipped in from other sources each year. About 85 per cent of the population of the State is non-agricultural, and these consumers are not far distant from the farms where the crop is grown.

The Ohio farm price has averaged somewhat higher than farm prices in states supplying Ohio's deficit, roughly by an amount about equal to the differential in the costs of transportation.

**TABLE 1.—Farm Prices of Potatoes in Ohio and in the More Important Late States Shipping into Ohio, 1933 to 1937 Inclusive**

State	Season average prices per bushel					5-year weighted average
	1933	1934	1935	1936	1937	
	<i>Dol.</i>	<i>Dol.</i>	<i>Dol.</i>	<i>Dol.</i>	<i>Dol.</i>	<i>Dol.</i>
Ohio.....	1.19	0.59	0.69	1.21	0.81	0.86
Idaho.....	.52	.48	.48	.92	.30	.52
Maine.....	.70	.20	.66	.92	.42	.56
Michigan.....	.74	.30	.55	1.02	.57	.61
Minnesota.....	.61	.37	.42	1.30	.48	.56
Wisconsin.....	.70	.33	.51	1.02	.52	.58

In 1936, 479 growers in northeastern Ohio reported to the Ohio Agricultural Experiment Station information relating to 1,301,222 bushels of potatoes harvested. Of these, 895,472 bushels could be catalogued by places of sale or other disposal and by types of buyers. Owing to unfavorable growing conditions in 1937 the amounts harvested and reported for similar classification fell far short of these amounts; 166 growers harvested only 222,399 bushels, and reported only 55,299 bushels whose disposal could be catalogued.

More than one-third of the total amount harvested by these growers was sold to buyers who came to the farms. As a matter of fact, buyers took at the farms more than 43 per cent of the amount actually sold in 1936 and almost 60 per cent in 1937. Moreover, the remainder was marketed within a small area, in so far as places of delivery were reported. Although no data are at hand to reveal costs of marketing these potatoes, it may be inferred that costs were small owing to markets' being close at hand and many buyers' being willing to seek supplies at their source.

**TABLE 2.—Places Potatoes Were Delivered to Buyers by Growers Reporting, 1936 and 1937**

Places of delivery	Quantity delivered 1936		Quantity delivered 1937	
	<i>Bu.</i>	<i>Pct. of total</i>	<i>Bu.</i>	<i>Pct. of total</i>
Buyers at farms.....	348,707	38.94	21,059	38.08
Near-by towns and grading stations.....	228,942	25.57	6,333	11.45
Akron.....	7,456	.83		
Cleveland.....	55,505	6.20	6,074	10.98
Columbus.....	43,790	4.89		
Pittsburgh.....	10,870	1.21		
Warren.....	4,599	.51		
Youngstown.....	27,057	3.02	1,667	3.01
Other cities.....	47,873	5.35	184	.34
Harvested, but not sold*	94,475	10.55	15,889	28.73
Reported, but impossible to classify.....	26,198	2.93	4,093	7.41
Total.....	895,472	100.00	55,299	100.00

\*Shrinkage, consumed on farms, saved for seed, etc.

It is impossible to say what part of the total went ultimately to each of the cities named. Doubtless a large part of the quantity sold to buyers (largely truckers) at the farms was sold by them in turn to wholesalers or retailers or consumers in cities and towns in this general area. It is known that considerable quantities were trucked into the West Virginia coal fields. The cooperative organization which is an active operator in the northeastern Ohio potato deal sold in southern Ohio, in West Virginia, and in Pennsylvania, as well as locally. In the main, however, it can be said that the market was primarily local, bounded by Cleveland, Pittsburgh, and Columbus.

An interesting and in some respects encouraging aspect of the marketing of these potatoes is found in their wide distribution among various types of buyers. These growers were not compelled to rely wholly upon a single trade channel. City wholesalers and commission merchants, itinerant truckers, the cooperative sales organization, and retailers shared in the bulk of the business. Even sales direct to consumers accounted for large quantities, amounting in 1936 to 4.16 per cent of the total harvested (or 4.65 per cent of the amount actually sold) and in 1937 to 18.67 per cent of the total harvested (or 29.3 per cent of the amount actually sold).

**TABLE 3.—Types of Agencies Handling Potatoes Directly from Growers Reporting, 1936 and 1937**

Agency taking direct delivery	Quantity of potatoes handled			
	1936		1937	
	<i>Bu.</i>	<i>Pct. of total</i>	<i>Bu.</i>	<i>Pct. of total</i>
City wholesalers and commission merchants.....	128,919	14.40	11,428	20.67
Retailers.....	117,351	13.10	6,686	12.09
Truckers (at farms).....	283,765	31.69	1,332	2.41
Consumers.....	37,230	4.16	10,326	18.67
Cooperative sales organization.....	214,835	23.99	3,702	6.70
Miscellaneous.....	5,665	.63	1,805	3.26
Harvested, but not sold*.....	94,475	10.55	15,889	28.73
Reported, but impossible to classify.....	13,232	1.48	4,131	7.47
Total.....	895,472	100.00	55,299	100.00

\*Shrinkage, consumed on farms, saved for seed, etc.

Data in Tables 2 and 3 should not be interpreted as revealing changes in relative importance of the methods of marketing and agencies employed by these growers in 1936 and 1937. Reports were not received from identical groups of growers in both years and some growers who reported both years had partial or complete crop failures in 1937 which affected the results markedly. The cooperative, for example, did not operate its grading stations in some areas in 1937 because of lack of volume available. Although its volume in northeastern Ohio declined in 1937 the quantities reported in Table 3 cannot in any sense be interpreted as a measure of that decline.

# INDEX NUMBERS OF PRODUCTION, PRICES, AND INCOME

J. I. FALCONER

In August the prices received for Ohio farm products were 26 per cent lower than a year ago. Crop prices had declined more than livestock prices. It appears now that the cash income to the Ohio farmer from the sale of farm products for 1938 will be approximately 20 per cent below that of 1937.

## Trend of Ohio Prices and Wages, 1910-1914=100

	Wholesale prices, all commodities U. S.	Weekly earnings N. Y. State factory workers	Prices paid by farmers	Farm products prices U. S.	Ohio farm wages	Ohio farm real estate	Ohio farm products prices	Ohio cash income from sales
1913.....	102	.....	101	101	104	100	105	101
1914.....	99	100	100	101	102	102	105	108
1915.....	102	101	105	98	103	107	106	111
1916.....	125	114	124	118	113	113	121	121
1917.....	172	129	149	175	140	119	182	199
1918.....	192	160	176	202	175	131	203	240
1919.....	202	185	202	213	204	135	218	266
1920.....	225	222	201	211	236	159	212	226
1921.....	142	203	152	125	164	134	132	130
1922.....	141	197	149	132	145	124	127	130
1923.....	147	214	152	142	166	122	134	144
1924.....	143	218	152	143	165	118	133	146
1925.....	151	223	157	156	165	110	159	174
1926.....	146	229	155	145	170	105	155	177
1927.....	139	231	153	139	173	99	147	165
1928.....	141	232	155	149	169	96	154	156
1929.....	139	236	153	146	169	94	151	165
1930.....	126	226	145	126	154	90	128	137
1931.....	107	207	124	87	120	82	89	100
1932.....	95	178	107	65	92	70	63	73
1933.....	96	171	109	70	74	59	69	85
1934.....	110	182	123	90	77	63	85	98
1935.....	117	191	125	108	87	66	110	127
1936.....	118	199	124	114	100	71	118	147
1937.....	126	215	131	121	118	75	128	161
1936								
July.....	118	198	123	115	105	.....	121	189
August.....	119	202	126	124	.....	.....	131	183
September.....	119	198	127	124	.....	.....	127	169
October.....	119	202	127	121	108	.....	124	164
November.....	120	201	127	120	.....	.....	123	158
December.....	123	211	128	126	.....	.....	127	160
1937								
January.....	125	209	130	131	104	.....	128	151
February.....	126	211	132	127	.....	.....	127	141
March.....	128	218	132	128	.....	75	129	157
April.....	128	219	134	130	118	.....	134	170
May.....	127	219	134	128	.....	.....	135	164
June.....	127	220	134	124	.....	.....	134	162
July.....	128	218	133	125	123	.....	138	191
August.....	128	220	132	123	.....	.....	135	171
September.....	128	215	130	118	.....	.....	129	164
October.....	125	214	128	112	127	.....	123	156
November.....	122	205	127	107	.....	.....	116	156
December.....	119	207	126	104	.....	.....	114	142
1938								
January.....	118	201	126	102	115	.....	109	135
February.....	116	204	126	97	.....	.....	105	121
March.....	116	205	125	96	.....	74	106	130
April.....	115	204	125	94	116	.....	104	126
May.....	114	201	125	92	.....	.....	104	132
June.....	114	202	124	92	.....	.....	106	131
July.....	115	205	123	95	119	.....	106	152
August.....	114	.....	122	92	.....	.....	100	.....
September.....	.....	.....	.....	.....	.....	.....	.....	.....

## NEW MONOGRAPH BULLETINS

**Publications of the Ohio Agricultural Experiment Station may be obtained by sending a request to the Mailing Room, Ohio Agricultural Experiment Station, Wooster, Ohio.**

**Bulletin 586. Greenhouse Potted Plants. G. H. Poesch.** The discussion of the major potted plants and their culture presented in this bulletin is based on the best accepted commercial practices and the results of experiments conducted for several years at the Ohio Agricultural Experiment Station and the Ohio State University.

**Bulletin 587. The Farm Business from 1929 to 1935 on One Hundred Forty-One Ohio Farms. J. H. Sitterley and J. I. Falconer.** The authors observe some of the effects of the radically changing conditions between 1929 and 1935 on net cash income, record the recognizable adjustments made, and attempt to determine, in so far as possible from the records, some of the characteristics of those farms that obtained the largest and those that obtained the smallest incomes during this period.

**Bulletin 588. Better Methods of Seeding Meadows. L. E. Thatcher, C. J. Willard, and R. D. Lewis.** Any program of increasing the proportion of land in soil-building sod crops must first of all attack the problem of obtaining seedings. Because of the vital importance of this problem, an important part of the experimental work of the Department of Agronomy during the last 10 years has consisted of tests at Wooster, Columbus, and the outlying experiment farms, designed to study the principles involved in obtaining seedings. The results of this experimental work, together with practical seeding suggestions, are reported in this bulletin.

**Bulletin 589. Soil Erosion in Ohio. G. W. Conrey, J. S. Cutler, and A. H. Paschall.** This bulletin is designed to present the extent of the erosion problem in Ohio, and to point out in a general way, the relationship of erosion to land use. A generalized erosion map of the State is included.

**Bulletin 590. Tobacco Cultural and Fertility Tests. M. A. Bachtell, R. M. Salter, and H. L. Wachter.** The tobacco investigations of the Ohio Agricultural Experiment Station, centralized at the Southwestern Experiment Farm in the Miami Valley tobacco district, have covered a wide range of fertility and cultural practices with the result that there is now available information concerning most of the phases of tobacco growing from the time the plant beds are started until the mature plants are cut and hung in the barn. Such information is presented in this bulletin.

**Bulletin 591. Spraying Program and Pest Control for Fruit Crops (also published as Bulletin 128 by the Agricultural Extension Service, The Ohio State University).** This bulletin discusses the standard spray materials now offered for sale and suggests proper combinations that will control both insects and diseases without causing spray injury to the fruit and foliage. It has been prepared after considerable discussion of the effectiveness and safety of the materials and combinations suggested, and these have been thoroughly tested and approved.

**Bulletin 592. Progress of Agricultural Research in Ohio, 1936-1937 (The Fifty-sixth Annual Report of the Ohio Agricultural Experiment Station).** This publication contains the report of the Director of the Ohio Agricultural Experiment Station and includes accounts of the experimental work carried on during the year by the Experiment Station Departments of Agronomy, Animal Industry, Botany and Plant Pathology, Dairy Industry, District and County Farms, Home Economics, Rural Economics, Agricultural Engineering, Entomology, Forestry, and Horticulture. It also lists the publications of the Ohio Station during the year and includes a climatological summary of the year 1936, as well as the report of the Station Bursar.

**Bulletin 593. Ohio Agricultural Statistics. 1936. G. S. Ray, L. H. Wiland, and P. P. Wallrabenstein.** This bulletin contains preliminary county estimates of the acreage, yield per acre, and total production of corn, winter wheat, oats, tame hay, and potatoes for 1936; revised estimates of tame hay for 1929 through 1935, corn for 1935, and potatoes for 1935; preliminary county estimates of the numbers of livestock on farms January 1, 1937, and revised estimates for the numbers on hand January 1, 1935. It includes also revised figures for all tame hay, annual legume hay, soybeans, hay seeds, and the number of cows and heifers, 2 years old and over kept mainly for milk, which have become available since the publication of the previous statistics. Included in this bulletin also are reports of average Ohio farm wages by the month and by the day, farm prices of Ohio farm products, and the estimated gross cash income of Ohio's agricultural industry from the sale of products and government payments for the period 1910-1936.

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# The Bimonthly Bulletin

Vol. XXIV

January-February, 1939

No. 196

## Ohio Agricultural Experiment Station

WOOSTER, OHIO, U. S. A.



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*Edmund Secrest*  
Director



**Winter at the Ohio Agricultural Experiment Station**

## STATION TO GIVE REGULAR BROADCASTS

During the next 3 months the Ohio Agricultural Experiment Station will offer four programs to radio listeners in Ohio.

DATE	TIME	SUBJECT	SPEAKER
January 16	1 p. m.	Hybrid Corn	G. H. Stringfield
February 6	1 p. m.	The Changing Dairy Industry	C. C. Hayden
February 27	1 p. m.	Early Spring Work in the Orchard	C. W. Ellenwood
March 20	1 p. m.	Serving the People of Ohio Through Research	W. E. Krauss

As part of its program of service to the people of Ohio, the Experiment Station is cooperating with the county agricultural and home demonstration agents of Portage and Summit Counties in putting on a regular series of weekly radio broadcasts. This series, known as the Farm News program, comes regularly every Monday afternoon at 1 o'clock from radio station WADC of Akron, Ohio (1320 kilocycles). The Experiment Station has a program every 3 weeks.

The afternoon of January 16 the Experiment Station and the Bureau of Plant Industry, United States Department of Agriculture, cooperating, will present G. H. Stringfield, well known to the people of Ohio as an authority on hybrid corn. "Hybrid Corn" will be Mr. Stringfield's subject.

Present-day economic conditions; the soil conservation program's promotion of more forage crops, less grain; the newer knowledge of vitamins; and the new methods of cattle improvement make the dairy industry truly "The Changing Dairy Industry". Recognizing the significance of these problems to the dairymen of Ohio, C. C. Hayden, Chief of the Dairy Department of the Ohio Agricultural Experiment Station, will discuss them with his radio listeners Monday afternoon, February 6, at 1 p. m.

C. W. Ellenwood of the Horticulture Department will bring timely information to the microphone February 27 when he talks on "Early Spring Work in the Orchard". Mr. Ellenwood will take up a number of matters that must be considered before fruit trees are planted, and will discuss the most important things to be done in the spring to the orchard already planted.

The primary purpose of the Ohio Agricultural Experiment Station is to solve agricultural problems. These agricultural problems are so far-reaching that every individual in the State is affected by them, either directly or indirectly. How the Station goes about solving these problems will be the main theme of "Serving the People of Ohio Through Research", the program for March 20. W. E. Krauss will be the speaker.

# THE CLEANING OF MILK UTENSILS

L. H. BURGWARD

It has always been advised that milk utensils be rinsed with very hot water when washed, and steamed if possible. The purpose of this is not only to kill bacteria, but also to dry the utensils so that any bacteria which still remain alive (and there are usually many) will not be able to multiply.

Some tests conducted by the Bureau of Dairy Industry show the importance of drying the utensils. In several series of tests it was found that the bacterial count in washed but undried milk cans increased from a few thousand to several hundred million in 24 hours.

Tests conducted by the Station also showed exceedingly higher bacterial counts in wet utensils at the end of 24 hours than in utensils washed and treated in the same manner except that they were dried after washing.

Bacterial counts were obtained on 5-gallon milk cans which had been washed and dried in the same manner. After drying, one set was wet with sterile water and the lids were put on; the other set remained dry. After they had been stored for 24 hours at room temperature (70-75° F.) bacterial counts were made. The results are given in table 1.

TABLE 1.—Bacterial counts from dry and wet milk cans

Bacterial count in—		
Freshly washed can	Wet can (24 hours)	Dry can (24 hours)
5,000	110,000,000	9,000
9,000	75,000,000	7,000
20,000	210,000,000	18,000
9,000	99,000,000	15,000
21,000	125,000,000	10,000
13,000	140,000,000	35,000
7,000	89,000,000	21,000
15,000	190,000,000	16,000
3,000	66,000,000	10,000
28,000	160,000,000	31,000

A 5-gallon can would hold 18,920 cubic centimeters of milk; so if one were to place milk in either the freshly washed can or in the dry can at the end of 24 hours, one would be introducing less than one bacterium per cubic centimeter of milk. If one were to put milk into the wet can at the end of 24 hours without rerinsing, the milk would be contaminated with 6,680 bacteria per cubic centimeter.

All dairy utensils should be washed immediately after use. First they should be rinsed with cold or lukewarm water, then washed with hot water containing a mild alkali washing powder (not a soap powder) and a good stiff brush that will get into the corners. A cloth is not suitable. Finally, the utensils should be rinsed with scalding hot water, steamed if possible, and inverted on a clean rack to dry.

Rinsing utensils with a chlorine solution containing 100 parts per million of available chlorine and draining thoroughly just before use will aid materially in reducing the numbers of bacteria in the utensils.

# PRESERVING CIDER BY CARBONATION

H. D. BROWN AND C. W. FOULK

To test the preservation of cider by carbonation, several experiments were started by the Horticulture Department during the fall of 1937. In all instances the cider was preserved satisfactorily.

In one test 5 gallons of clarified cider were held at room temperature (70-75° F.) in a tank subjected to a carbon dioxide pressure of 100 to 125 pounds per square inch for 3 months. The cider was clarified by forcing the untreated portion (that which did not settle out after standing 12 hours in a bowl) through cotton fiber in a Karl Kiefer filter. After 3 months samples were examined and found to be almost if not entirely free from yeasts. Ten people familiar with cider were unable to detect the least taste of alcohol after the completion of the test. A faint carbonation taste could, however, be detected. A relatively small amount of carbon dioxide was retained, partly at least because of the high temperatures at which the cider was held. These high temperatures were maintained to test the efficiency of carbon dioxide in inhibiting the growth of spoilage organisms. At the completion of the 3-month period the cider seemed to have a slight cooked taste. This may possibly be better termed a storage deterioration flavor, because the cider was not subjected at any time to any temperatures higher than those of the room. During carbonation the temperature fell several degrees below room temperature because the gaseous carbon dioxide liberated from the tank had a cooling effect. At the completion of this test some of the cider was poured into unsterilized bottles which were then capped. Some of these bottles were completely filled and others only partially (four-fifths) filled. Three months later these samples were examined and found to be free from detectable alcoholic fermentation. No gaseous pressure had developed. However, an unsightly precipitate had formed and the flavor was poor. The precipitate included some apparently dead yeast cells, some mold mycelia, and possibly some bacteria.

In an effort to see if lower pressures were also effective, some cider concentrated under 25 to 26 inches of vacuum was carbonated in bottles at 3½ volumes (approximately 47 pounds of pressure at 70° F.). The cider clarified as for the preceding test was concentrated in a 16-inch stainless steel vacuum pan. One-, two-, three-, and four-ounce samples of this concentrate, which contained 75 per cent of sugar, were placed in 12-ounce bottles and carbonated.<sup>1</sup> In this process the cold cider concentrate was placed in the bottom of the bottle; the bottle was filled with cold carbonated water and capped immediately. After 3 months these samples were examined and found to be free from yeasts in all instances. No excessive gaseous fermentation was evident at any time and no bottles were cracked. However, the cider all had a decided cooked taste, and its acidity combined with the excessive carbonation produced a very undesirable flavor. The bottles were all kept at room temperatures in an upright position. It is possible that the crown seals allowed a slow gas leakage. The lot containing 4 ounces of cider concentrate was far superior to the lots that contained less cider.

---

<sup>1</sup>At the Voss Bottled Beverage Company at Columbus, Ohio, through the generous cooperation of the plant foreman, Harold Forst.

This test was repeated with a concentrate secured by centrifuging frozen cider at 1,200 revolutions per minute. Four, five, and six ounces of this concentrate, which contained 26 per cent of sugar, were used in the 12-ounce bottles. This carbonated cider was pronounced by all who tasted it to be the best carbonated cider that they had ever tasted. It was highly carbonated, however, and would be objectionable to those who dislike this type of drink. The 4- and 5-ounce amounts proved most satisfactory. At the end of 3 months the samples were examined under the microscope and found to be free from yeasts and molds.

At the conclusion of these tests another batch of cider was made, one-half of which was filtered. Various amounts of filtered cider were placed in eight of these 12-ounce bottles and the bottles capped. Unfiltered cider was treated in a similar manner. Some bottles were inverted and some placed in an upright position. At the end of 3 months the samples were examined. Four had burst from excessive pressure. All the remainder developed a very high pressure and most of the contents escaped when the crown seal was suddenly removed. All contained large numbers of yeast cells and bacteria and had a very undesirable flavor. Obviously the cider did not develop sufficient carbon dioxide to have a preservative effect before an undesirable flavor developed.

# PARITY PRICES FOR OHIO FARM PRODUCTS

J. I. FALCONER

Parity prices have come to be considered a goal for farm product prices. By parity price is meant a price for farm products that would give the same purchasing power as prevailed during the period from 1910 to 1914. In October 1938 farmers were paying 21 per cent more for the commodities which they purchased than in the period 1910 to 1914. Parity prices, therefore, for farm products in October of 1938 would mean prices 21 per cent above the prices received for the same commodities during the years 1910 to 1914.

In table 1 are given: the October 1938 selling price for the leading Ohio farm products; the price which the same commodity would have been if prices had been at the parity level; and, in the last column, the per cent which the October 1938 price was of parity. It will be noted that as an average, October 1938 prices were only 79 per cent of parity. The level of individual commodity prices varied widely. Hay at \$5.20 per ton and 33 per cent of parity was the lowest. Lambs at \$7.30 per hundredweight and 10 per cent above parity were the highest. In general, crop prices were at a lower level than livestock prices. Five of the 16 commodities listed were at parity or above, namely, lambs, eggs, chickens, beef cattle, and veal calves. During the first 9 months of 1937, Ohio farm product prices were approximately at a parity level; the decline to 79 per cent of parity has taken place since that date.

TABLE 1.—Prices of Ohio farm products

	Unit	October 1938 price, dollars	October parity price, dollars	Per cent October 1938 price was of parity
Corn.....	Bu.	0.42	0.82	51
Wheat.....	Bu.	.59	1.18	50
Oats.....	Bu.	.24	.47	51
Potatoes.....	Bu.	.65	.84	77
Hay.....	Ton	5.20	15.97	33
Hogs.....	Cwt.	7.40	9.44	79
Beef cattle.....	Cwt.	7.10	6.98	102
Veal calves.....	Cwt.	9.70	9.66	100
Lambs.....	Cwt.	7.30	6.65	110
Sheep.....	Cwt.	3.05	4.32	70
Wool.....	Lb.	.22	.26	85
Eggs.....	Doz.	.29	.28	104
Chickens.....	Lb.	.15	.144	104
Butterfat.....	Lb.	.22	.27	82
Milk Cows.....	Head	57.00	62.04	90
Horses.....	Head	103.00	195.65	55
Average.....				79

# INDEX NUMBERS OF PRODUCTION, PRICES, AND INCOME

J. I. FALCONER

In October the prices received for Ohio farm products were 22 per cent lower than 1 year ago. The agricultural income for the month was 15 per cent below that of 1 year ago. A larger volume of sales made up in part for the lower prices received. During the same period the price of commodities purchased by farmers declined 6 per cent. During October 1938, Ohio farm prices were 79 per cent of parity.

Trend of Ohio prices and wages, 1910-1914=100

	Wholesale prices, all commodities U. S.	Weekly earnings N. Y. State factory workers	Prices paid by farmers	Farm products prices U. S.	Ohio farm wages	Ohio farm real estate	Ohio farm products prices	Ohio cash income from sales
1913.....	102	.....	101	101	104	100	105	101
1914.....	99	100	100	101	102	102	105	108
1915.....	102	101	105	98	103	107	106	111
1916.....	125	114	124	118	113	113	121	121
1917.....	172	129	149	175	140	119	182	199
1918.....	192	160	176	202	175	131	203	240
1919.....	202	185	202	213	204	135	218	266
1920.....	225	222	201	211	236	159	212	226
1921.....	142	203	152	125	164	134	132	130
1922.....	141	197	149	132	145	124	127	130
1923.....	147	214	152	142	166	122	134	144
1924.....	143	218	152	143	165	118	133	146
1925.....	151	223	157	156	165	110	159	174
1926.....	146	229	155	145	170	105	155	177
1927.....	139	231	153	139	173	99	147	165
1928.....	141	232	155	149	169	96	154	156
1929.....	139	236	153	146	169	94	151	165
1930.....	126	226	145	126	154	90	128	137
1931.....	107	207	124	87	120	82	89	100
1932.....	95	178	107	65	92	70	63	73
1933.....	96	171	109	70	74	59	69	85
1934.....	110	182	123	90	77	63	85	98
1935.....	117	191	125	108	87	66	110	127
1936.....	118	199	124	114	100	71	118	147
1937.....	126	215	131	121	118	75	128	161
1936								
July.....	118	198	123	115	105	.....	121	189
August...	119	202	126	124	.....	.....	131	183
September..	119	198	127	124	.....	.....	127	169
October.....	119	202	127	121	108	.....	124	164
November...	120	201	127	120	.....	.....	123	158
December...	123	211	128	126	.....	.....	127	160
1937								
January...	125	209	130	131	104	.....	128	151
February...	126	211	132	127	.....	.....	127	141
March.....	128	218	132	128	.....	75	129	157
April.....	128	219	134	130	118	.....	134	170
May.....	127	219	134	128	.....	.....	135	164
June.....	127	220	134	124	.....	.....	134	162
July.....	128	218	133	125	123	.....	138	191
August.....	128	220	132	123	.....	.....	135	171
September..	128	215	130	118	.....	.....	129	164
October.....	125	214	128	112	127	.....	123	156
November...	122	205	127	107	.....	.....	116	156
December...	119	207	126	104	.....	.....	114	142
1938								
January...	118	201	126	102	115	.....	109	135
February...	116	204	126	97	.....	.....	105	121
March.....	116	205	125	96	.....	74	106	130
April.....	115	204	125	94	116	.....	104	126
May.....	114	201	125	92	.....	.....	104	132
June.....	114	202	124	92	.....	.....	106	131
July.....	115	205	123	95	119	.....	106	152
August.....	114	208	122	92	.....	.....	100	133
September..	114	214	121	95	.....	.....	102	134
October.....	113	.....	121	95	119	.....	96	132

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## Ohio Agricultural Experiment Station

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*Edmund Searest*  
Director



Apple orchard in bloom at the Ohio Agricultural Experiment Station

# EVAPORATION STUDIES III. TEN YEARS OF EVAPORATION AT WOOSTER AS MEASURED WITH BLACK AND WHITE ATMOMETERS

J. D. WILSON

Evaporation rates at Wooster have been measured each year since 1916, with but few exceptions. A standard United States Weather Bureau evaporation pan has been used, and the data cover the period from April 1 to October 31 in most instances (1). In 1926, an evaporation survey of Ohio was started in which white atmometers were used as evaporimeters (2). One of the stations included in this survey was located at Wooster. Daily readings from both black and white atmometers were begun on May 1, 1928, and continued until September 30. This procedure has been repeated each year since, and some of the data obtained have been discussed in various progress reports (3, 4).

TABLE 1.—Monthly evaporation values for the months of May to September from 1928 to 1937, inclusive, at Wooster, Ohio

Stated as corrected losses from black, spherical atmometers (B)

Month	1928	1929	1930	1931	1932	1933	1934	1935	1936	1937	10-year av.
	<i>Cc.</i>	<i>Cc.</i>	<i>Cc.</i>	<i>Cc.</i>	<i>Cc.</i>	<i>Cc.</i>	<i>Cc.</i>	<i>Cc.</i>	<i>Cc.</i>	<i>Cc.</i>	<i>Cc.</i>
May.....	1,452	1,052	1,450	1,102	1,330	1,050	1,788	1,076	1,358	1,129	1,279
June.....	984	1,290	1,704	1,212	1,494	1,741	1,739	1,129	1,586	1,101	1,398
July.....	1,316	1,292	1,992	1,598	1,636	1,857	1,595	1,246	1,700	1,243	1,547
August....	1,198	1,237	1,596	1,293	1,585	1,464	1,319	1,042	1,262	1,041	1,305
September.	1,258	940	1,246	1,033	1,345	1,027	965	1,065	1,150	1,031	1,106
5-month totals....	6,208	5,811	7,988	6,238	7,390	7,139	7,406	5,558	7,056	5,545	6,635

Livingston spherical, standardized, black and white atmometers (5), equipped with nonabsorbing mountings (6), have been used in this work. The data presented in the tables of this article are averages of the corrected losses from either two or three black and the same number of white instruments. The atmometers were freely exposed to the influence of all environmental factors by spacing them at regular intervals on a table of such height that the bulbs were 48 inches above the soil surface. The losses from the black (B) and white (W) instruments for 1928 to 1937, inclusive, are presented in tables 1 and 2 as monthly totals, and the differences between these two, or B—W, are given in table 3. These data of table 3 represent the effect of sunlight on evaporation.

1. Patton, C. A. 1934. Some observations on forty-six years of Ohio weather. Ohio Agr. Exp. Sta. Bull. 544: 1-32.
2. Wilson, J. D., and J. R. Savage. 1936. An evaporation survey of Ohio. Ohio Agr. Exp. Sta. Bull. 564: 1-53.
3. Wilson, J. D. 1935. Studies in evaporation. Ohio Agr. Exp. Sta. Ann. Rep. 52, Bull. 548: 85.
4. Wilson, J. D. 1938. Evaporation studies II. The influence of pan color on evaporation. Ohio Agr. Exp. Sta. Bimo. Bull. 23: 118-120.
5. Livingston, B. E. 1935. Atmometers of porous porcelain and paper, their use in physiological ecology. Ecology 16: 438-472.
6. Wilson, J. D. 1930. A modified non-absorbing valve for porous-cup atmometers. Science 71: 101-108.

TABLE 2.—Monthly evaporation losses from white atmometers at Wooster, Ohio (W)

Month	1928	1929	1930	1931	1932	1933	1934	1935	1936	1937	10-year av.
	<i>Cc.</i>	<i>Cc.</i>	<i>Cc.</i>	<i>Cc.</i>	<i>Cc.</i>	<i>Cc.</i>	<i>Cc.</i>	<i>Cc.</i>	<i>Cc.</i>	<i>Cc.</i>	<i>Cc.</i>
May.....	1,046	704	1,093	759	885	719	1,406	790	972	787	916
June.....	596	863	1,273	760	1,027	1,255	1,267	794	1,193	712	974
July.....	847	849	1,442	1,100	1,121	1,396	1,102	842	1,284	801	1,078
August.....	803	860	1,274	924	1,166	1,058	923	690	939	671	931
September.	961	655	992	706	1,014	732	664	704	851	716	800
5-month totals....	4,253	3,931	6,074	4,249	5,213	5,160	5,362	3,820	5,239	3,687	4,699

TABLE 3.—Influence of sunshine on evaporation at Wooster, Ohio

As determined by the difference between the losses from black and white atmometers (B—W)

Month	1928	1929	1930	1931	1932	1933	1934	1935	1936	1937	10-year av.
	<i>Cc.</i>	<i>Cc.</i>	<i>Cc.</i>	<i>Cc.</i>	<i>Cc.</i>	<i>Cc.</i>	<i>Cc.</i>	<i>Cc.</i>	<i>Cc.</i>	<i>Cc.</i>	<i>Cc.</i>
May.....	406	348	357	343	445	331	382	286	386	342	363
June.....	388	427	431	452	467	486	474	335	393	389	424
July.....	469	443	550	498	515	461	493	404	416	442	469
August.....	395	377	322	369	419	406	396	352	323	370	373
September.	297	285	254	327	331	295	301	361	299	315	307
5-month totals....	1,955	1,880	1,914	1,989	2,177	1,979	2,044	1,738	1,817	1,858	1,936

This period from 1928 to 1937 has been an interesting one from the ecological viewpoint because a drouth has prevailed during at least 4 of the 10 summers at Wooster. The drouth of 1930 was especially severe, and that of 1932 was nearly as detrimental to crop production at Wooster. Evaporation was also very high during the early summer of 1934, and rainfall was extremely low in May of that year (table 5). Wooster did not experience as severe a drouth in 1936 as did many other portions of the State or the United States, but evaporation was above the average. The evaporation rate was especially high during June and July of 1933, but the rainfall was nearly up to normal, and as a result, there was little evidence of drouth. Monthly evaporation values from the standard Weather Bureau pan are given for the 10-year period in table 4, and the corresponding rainfall totals, in table 5.

TABLE 4.—Evaporation from a standard United States Weather Bureau pan at Wooster, Ohio (P)

Month	1928	1929	1930*	1931	1932	1933	1934	1935	1936	1937	10-year av.
	<i>In.</i>	<i>In.</i>	<i>In.</i>	<i>In.</i>	<i>In.</i>	<i>In.</i>	<i>In.</i>	<i>In.</i>	<i>In.</i>	<i>In.</i>	<i>In.</i>
May.....	3.94	3.87	5.40	4.30	4.71	4.21	6.06	4.77	4.89	4.07	4.62
June.....	3.18	4.36	7.03	5.13	5.11	6.56	7.22	4.78	6.20	4.37	5.40
July.....	4.65	5.03	8.03	6.81	6.43	6.64	6.39	5.60	6.58	5.11	6.12
August.....	4.34	5.04	6.11	5.16	5.23	5.25	5.35	4.46	4.87	3.90	4.98
September.	3.12	3.20	4.40	3.77	3.80	3.60	3.93	3.68	4.12	3.74	3.73
5-month totals....	19.23	21.50	30.97	25.17	25.28	26.26	28.95	23.29	26.66	21.19	24.85

\*Estimated from black atmometer data.

TABLE 5.—Monthly rainfall totals at Wooster, Ohio (R)

Month	1928	1929	1930	1931	1932	1933	1934	1935	1936	1937	10-year av.
	<i>In.</i>	<i>In.</i>	<i>In.</i>	<i>In.</i>	<i>In.</i>	<i>In.</i>	<i>In.</i>	<i>In.</i>	<i>In.</i>	<i>In.</i>	<i>In.</i>
May.....	1.69	4.84	1.59	4.45	1.93	4.77	0.43	4.17	2.53	3.52	2.99
June.....	5.17	4.10	2.86	3.49	3.44	1.67	4.50	4.89	1.80	4.98	3.69
July.....	3.75	6.79	1.71	2.97	3.14	1.73	2.55	9.30	5.61	3.13	4.07
August....	4.03	1.26	2.64	4.68	2.01	3.85	4.21	9.53	5.46	2.75	4.04
September.	.65	1.66	2.53	3.48	1.93	4.23	6.11	1.96	2.66	2.62	2.78
5-month totals....	15.29	18.65	11.33	19.07	12.45	16.25	17.80	29.85	18.06	17.00	17.57

As mentioned in a previous paper (4), the variations in evaporation rates from the standard pan correspond more closely to those from the black than to those from the white atmometer. For instance, the monthly variations are in the same order in tables 1 and 4 in 5 of the 10 years involved (1930, 1931, 1933, 1935, and 1936); whereas this is true in only 2 years (1931 and 1936) when the losses from the pan and the white atmometer are compared (tables 2 and 4). Since the difference between the losses from the black and white atmometers is a measure of the effect of radiation (sunshine) on evaporation (B—W values of table 3), it may be assumed that the standard pan is relatively more sensitive to sunshine than is the white atmometer and that the metal of the pan and the contained water mass must absorb a considerable portion of the radiant energy which strikes it. This absorbed energy is, of course, in turn dissipated by an increase in evaporation and thus affects the total loss from the pan as well as from the black atmometer (4).

When the 10-year averages of monthly losses from the three types of instruments are compared (last column to the right in tables 1, 2, and 4), it is evident that the relative order of magnitude is the same in each instance. July values are largest and these are followed by those of June, August, May, and September in decreasing order. This arrangement also holds for the B—W values of table 3. If the relative monthly values of the commonly measured ecological factors which influence the evaporation rate (tables 5 to 9, inclusive) are examined in table 15, it will be seen that none of them assumes the above order. This would make it seem likely that it is only the combined effect of all these factors that causes the summed results, as expressed by the average monthly evaporation rates, to assume the above order. Since the average monthly values of B—W (table 3), which represent the effect of radiation (principally evaluated by sunlight duration and intensity) on the total loss from the black atmometer (table 1) vary in the same order, it seems reasonable to suppose that they play an important part in determining this order. The percentage of total evaporation which is due to radiation is shown in table 13, and similar percentage relationships between the B—W values and those representing the corresponding monthly losses from the white atmometer (W) are presented in table 14.

Returning to the data of tables 1 and 2, we find that the 5-month totals of evaporation were above the average in 1930, 1932, 1933, 1934, and 1936 and below it in the remaining 5 of the 10 years. The maximum 5-month loss occurred in 1930 and the minimum in 1937 from both the black (B) and white (W) instruments. The B loss was 20 per cent above the average in 1930 and 16 per cent below it in 1937. The corresponding W values show an excess of

29 per cent in 1930 and a deficiency of 22 per cent in 1937. All monthly evaporation values were low in 1935, a year of comparatively high rainfall and relative humidity and low sunshine and temperature values. The highest monthly total of evaporation occurred in July 1930, a month of low rainfall and humidity accompanied by high temperature and radiation values. July 1933 was another month of high evaporation. June 1928 and September 1929 were months of low evaporation, although there was no marked deficiency of temperature or excess of rainfall during these months.

The data of the standard evaporation pan (table 4) for the years of 1928, 1929, and 1930 are hardly comparable with those for 1931 to 1937, inclusive, since the pan was moved in the spring of 1931 from its previous position of relatively low evaporation and wind velocities to a new one of greater exposure near the atmometer site. Data for 1930 were incomplete, and the values shown in table 4 for that year were calculated from a study of the relationships existing between the black atmometer and pan data for the years of 1931 to 1937, inclusive; the black atmometer data for 1930 were known. As mentioned in a previous paper (4) the evaporation losses from the standard pan show a greater spread between the maximum values of July and the smaller ones of May and September than is the case with either the black or white atmometer losses (table 15). The losses from a shallower pan would undoubtedly correspond more closely to the atmometers in this respect because of a quicker response to variations in the radiation and temperature factors. A superficial comparison of the data of table 15 indicates that the monthly variations in the losses from the standard pan correspond most closely with those of the radiation factor (sunlight intensity and duration, S and B—W in table 15) and progressively less closely with temperature, relative humidity, and wind velocity.

The rainfall data of table 5 are of interest in this study chiefly because of their relationship to the corresponding evaporation values and the correlation between these two sets of values and the onset and duration of drouth periods. Although this relationship between evaporation and rainfall [the reciprocal of the rainfall-evaporation ratio as introduced by Transeau (7)] will be discussed in considerable detail in a later paper, with particular reference to its influence on crop yields at Wooster, some mention will be made of it here. The data relative to the evaporation-rainfall ratio for the 10-year period under consideration are given in table 12. The values given in table 12 were determined by dividing the black atmometer losses (table 1) by the rainfall totals (table 5), after transposing the former into inches of evaporation by using the 7-year-average conversion values of table 11. As may be seen by an inspection of the data in table 12, months with large E/R values (over 2.00) were dry; whereas rainfall was plentiful and evaporation correspondingly low when E/R is represented by values less than 1.00. It is interesting to note that rainfall exceeded evaporation in only 13 of the 50 summer months represented in table 12. On the other hand, evaporation exceeded rainfall by 50 per cent in 24 of the 50 months and was at least twice as great in 18 of the 50.

The value of the E/R (or R/E) ratio is of considerable economic importance in its effect upon crop yields, and more broadly, upon the distribution of vegetation types, but an arbitrary division into monthly units as is done in the data of table 12 does not allow the best use to be made of it in a study of crop yields or the prediction of such yields. This is true largely because the growth periods of particular crops are not delimited by monthly boundaries, nor are these

growth periods of the same length or date of beginning for different crops. Also, just what constitutes a drouth, either in its inception or its duration, is difficult to define, and different crops show a wide variation in their growth response to the initiation of a deficiency in soil moisture and the concomitant increase in evaporation rates. In other words, a lawn may show the effects of dry weather with an accumulated evaporation of about 2 inches (525 cc. of corrected evaporation from the black atmometer) since the last rain of 0.5 inch or more (8); whereas corn may not evidence a rolling of its leaves until this summation reaches about 3.0 inches (or 800 cc.); and for such crops as the tree fruits the ultimate total which would bring about a definite diminution in twig or fruit growth is difficult to estimate (9).

Alexander (10) in a discussion of drouths in Ohio accepts the definition of Henry as fairly satisfactory. This is as follows: "A drouth is considered to exist whenever the rainfall for a period of 21 days or longer is but 30 per cent of the average for the time and place." Such periods have occurred several times at Wooster during the 10 years under consideration. To pick them superficially from the data of table 12 we should consider only those months which show an E/R value in excess of 3.30. These would include September 1928, August 1929, May and July of 1930, June and July of 1933, May of 1934, and June of 1936, and possibly May of 1928, depending on the April weather which preceded it. Any of these may be in error, because evaporation may have been sufficiently in excess of rainfall over comparatively short periods to influence the monthly value unduly, and other actual drouth periods of this sort may be hidden by overlapping from month to month. A detailed examination of the daily data (of such quantity as to be impractical of publication here) indicates that the intervals listed in the following tabulation may be classified as drouth periods on the basis of the Henry definition. The first column represents the percentage of the normal expectancy for rain which actually fell during any given period (1); and the second, or middle, column shows the percentage relationship between the evaporation which occurred during a given period and the actual rainfall total for the same period. In the last column to the right the approximate value of the E/R ratio (the number of times evaporation was in excess of rainfall) is indicated for each period

	Actual rainfall was following percentage of—		Approximate E/R ratio
	Normal rainfall	Evaporation	
August 19 to September 30, 1928.....	22	16	6
May 22 to June 18, 1929.....	18	14	7
August 4 to September 25, 1929.....	30	24	4
May 20 to June 15, 1930.....	10	6	16
July 7 to August 3, 1930.....	29	14	7
May 18 to June 15, 1932.....	7	5	20
July 23 to August 17, 1932.....	25	15	6
June 6 to July 1, 1933.....	24	14	7
July 4 to August 2, 1933.....	1	1	100
May 1 to June 1, 1934.....	10	9	11
May 20 to June 29, 1936.....	27	18	5
August 30 to September 23, 1936.....	14	11	9

8. Wilson, J. D., and F. A. Welton. 1935. The use of an evaporation index in watering lawns. Ohio Agr. Exp. Sta. Bimo. Bull. 20: 112-119.

9. Howlett, F. S. 1938. Relation of soil moisture content to apple tree growth and fruiting. Ohio Agr. Exp. Sta. Spec. Cir. 54: 26-28.

10. Alexander, W. H. 1934. Drouths in Ohio. Eng. Exp. Sta. News (Ohio) 6: 5: 7-9.

It is plain that those drouth periods which fell in late August and September of 1928, 1929, and 1936 were not as important in affecting crop yields for those years as were those periods which occurred earlier in the growing season. They were important, of course, in their relation to the seeding of fall wheat. Corn yields are greatly influenced by the weather from early July to early August (11). In this respect the periods falling in these general time limits in 1930 and 1933 were important in regulating yields of this crop. When two of these periods fall close together in a given season, as they did in 1930 and 1933, crops are likely to suffer severely. Vegetable gardens often get away to a poor start in the spring when May and early June are extremely dry, as they were in 1929, 1930, 1932, 1934, and 1936. Early drouths which started in May were more frequent in this period of 10 years than were those beginning in any other month. The period from July 4 to August 2, 1933, was remarkable for the small amount of rain that fell. This was an extremely small part of the normal rainfall expectancy and the actual evaporation which occurred during the period. In the very dry May of 1934 only 0.43 inch of rain fell, which was only about 11 per cent of the normal for that month and constituted only about one-sixteenth of the evaporation which took place during the month. In the wet month of August 1935, rainfall was nearly 3 times the normal and 2½ times the evaporation which occurred.

TABLE 6.—Average monthly values of mean temperatures at Wooster, Ohio

Month	1928	1929	1930	1931	1932	1933	1934	1935	1936	1937	10-year av.
	°F.	°F.	°F.	°F.	°F.	°F.	°F.	°F.	°F.	°F.	°F.
May.....	57.4	57.7	61.1	57.4	58.8	61.8	62.4	54.2	61.7	58.5	59.1
June.....	64.1	66.0	69.0	67.7	68.9	72.4	74.4	65.2	68.0	68.1	68.4
July.....	72.7	71.6	73.9	75.6	72.0	73.8	75.6	74.8	73.6	71.9	73.6
August....	62.7	66.4	70.5	71.8	70.8	70.6	69.5	72.0	73.7	73.2	70.1
September.	60.4	64.8	66.7	58.4	64.6	67.2	66.1	62.2	67.5	61.4	63.9
Monthly averages.	63.5	65.3	68.2	66.2	67.0	69.2	69.6	65.7	68.9	66.6	67.0

In connection with the temperature data of table 6, it is interesting to note that the 5-month periods of high, or above average, evaporation (1930, 1932, 1933, 1934, and 1936) were also intervals of high mean temperatures. Although 1930 produced the highest evaporation total, the mean temperatures of 1934, 1933, and 1936 exceeded that of 1930 in that order, indicating again that no one environmental factor alone determines what the evaporation rate will be over any extended period. July of 1931 and 1934 produced the highest monthly mean temperatures, but the evaporation from the black atmometer for these months was exceeded by that for July 1930 and 1933, for which the mean temperatures were at least 1.5° F. lower. Evaporation during August 1930, with its nearly normal mean temperature, was not exceeded by that of the warmer Augusts of 1931, 1935, 1936, and 1937. Also, the evaporation of June 1934 was practically the same as that of June 1933, although the mean temperature was 2° F. higher. In the cool month of May 1935, the evaporation was actually higher than it was during the warm May of 1933. Also, evaporation during the comparatively cool September of 1931 was higher than in September 1929, when the mean temperature for the month was more than 6° F. higher. July had the highest monthly average for mean temperature over the 10-year period. This was also

the month of highest evaporation. However, when we consider the August and June averages, we find that June, with a mean temperature lower than that for August, still had a higher average evaporation total than did the latter month. This same lack of correlation extends to May and September, and May, with an average mean temperature 4.8° F. below that of September, experienced an average daily evaporation 12 per cent greater than that for September.

Relative humidity data (table 7) were not available for Wooster and those for Columbus (about 90 miles southwest) are given. The fact is appreciated that these values are probably quite different from those which existed at Wooster on many individual days; however, the monthly averages are likely to be fairly similar and thus indicate moist or dry trends. The data are presented here chiefly to show the general correlation between low humidities and high evaporation rates during particular periods (12), even though most of this disappears in a comparison of the 10-year averages. Of the 5 driest years at Wooster, all but 1933 were in the group of the 5 years of lowest relative humidity at Columbus. The years of low evaporation and high humidity do not always agree so well, however. July 1930 was a month of low humidity and high evaporation. July 1936 was also a month of low humidity at Columbus, but, as was mentioned previously, Wooster was not so dry as much of the State that year, and as a result the evaporation was not so high as in 1930 and 1933. June 1928 was a month of exceptionally low evaporation and high relative humidity. This was also true of May 1933. The data of table 15 show that there is little correlation between the average monthly means of relative humidity and evaporation from the standard pan or the black atmometer.

TABLE 7.—Average monthly relative humidity at noon at Columbus, Ohio

Month	1928	1929	1930	1931	1932	1933	1934	1935	1936	1937	10-year month- ly av.
	<i>Pct.</i>	<i>Pct.</i>	<i>Pct.</i>	<i>Pct.</i>	<i>Pct.</i>	<i>Pct.</i>	<i>Pct.</i>	<i>Pct.</i>	<i>Pct.</i>	<i>Pct.</i>	<i>Pct.</i>
May.....	44	60	46	55	44	65	43	50	44	53	50
June.....	62	56	42	52	53	43	44	54	45	57	51
July.....	56	51	40	48	54	45	47	52	38	49	48
August....	56	51	47	62	45	52	54	57	49	54	53
September.	49	58	53	59	49	59	57	51	49	46	53
5-month averages.	53.4	55.2	45.6	55.2	49.0	52.8	49.0	52.8	45.0	51.8	51.0

The wind velocity data of table 8 were recorded by a four-cup anemometer placed about 3 feet above the ground and beside the standard evaporation pan. The anemometer was beside the pan in its first location (1928, 1929) and was moved with the pan to the present location in 1931. As was mentioned in the discussion relative to the evaporation from the standard pan, the data for 1928 and 1929 were taken in a position where wind movement was considerably reduced by surrounding vegetation. Wind data were not collected in 1930, as the standard evaporation pan was not in operation that year. Thus, only 7-year averages are given in the column on the right in table 8. It is apparent that there is little correlation between the monthly averages of hourly wind velocities and the monthly evaporation totals. This low degree of correlation between transpiration (and evaporation) and average wind velocity has been observed

by others (13). The high average velocity in May was far from able to overcome the lag in evaporation due to a relative deficiency in the values of various other factors, such as temperature and sunshine, so that it might bring about an evaporation total comparable to that for June and July.

TABLE 8.—Average hourly wind velocities at approximate level of evaporation pan (3 feet) at Wooster, Ohio

Month	1928	1929	1930	1931	1932	1933	1934	1935	1936	1937	7-year av.
	<i>Mi. per hr.</i>	<i>Mi. per hr.</i>	<i>Mi. per hr.</i>	<i>Mi. per hr.</i>	<i>Mi. per hr.</i>	<i>Mi. per hr.</i>	<i>Mi. per hr.</i>	<i>Mi. per hr.</i>	<i>Mi. per hr.</i>	<i>Mi. per hr.</i>	<i>Mi. per hr.</i>
May .....	1.79	1.74	.....	3.29	3.33	3.90	3.15	3.43	2.88	3.10	3.30
June .....	1.70	1.40	.....	2.37	2.60	2.92	3.04	2.88	2.89	2.50	2.74
July .....	1.29	1.32	.....	2.41	1.18	2.66	2.14	2.22	2.15	2.29	2.15
August .....	1.12	1.26	.....	2.90	2.46	2.65	2.12	2.42	2.66	1.76	2.42
September .....	1.50	1.22	.....	3.12	2.76	2.79	2.43	2.65	3.24	2.27	2.75
5-month averages	1.48	1.39	.....	2.85	2.46	2.99	2.57	2.72	2.77	2.39	2.68

Wind is particularly effective in influencing the evaporation rate at velocities varying between 0 and 4 miles per hour (14) if all other conditions are constant. This is the range in which most of the average hourly velocities given in table 8 fall, so that one might expect a high degree of correlation between these values and the evaporation totals of tables 1, 2, and 4, but these hourly averages are made up of many night periods of little or no air movement, many day periods of 4 to 10 miles per hour, and occasional short periods when the velocity varied from 10 to 20 or more miles per hour. Thus the average of all these variations cannot be expected to show any definite regulatory action on total evaporation over the period of a month. May of 1933 was a month of high winds, but since these were often accompanied by storms, the evaporation rate was little affected. July 1932 shows an average hourly velocity of only 1.18 miles per hour, nearly 45 per cent below the 7-year average for the month, and yet the evaporation total was about 6 per cent above the 10-year average.

TABLE 9.—Monthly totals of hours of sunshine at Wooster, Ohio (S)  
As recorded by the Marvin sunshine recorder

Month	1928	1929	1930*	1931	1932	1933	1934	1935	1936	1937	10-year av.
	<i>Hr.</i>	<i>Hr.</i>	<i>Hr.</i>	<i>Hr.</i>	<i>Hr.</i>	<i>Hr.</i>	<i>Hr.</i>	<i>Hr.</i>	<i>Hr.</i>	<i>Hr.</i>	<i>Hr.</i>
May .....	340	286	309	277	338	277	357	257	337	302	308
June .....	267	314	340	346	350	390	349	257	325	321	326
July .....	377	340	370	356	383	367	363	344	370	364	363
August .....	294	293	285	263	325	320	288	255	270	314	291
September .....	265	224	250	260	292	221	240	283	252	281	257
5-month totals....	1,543	1,457	1,554	1,502	1,688	1,575	1,597	1,396	1,554	1,582	1,545

\*Cleveland data.

The data of table 9 are the monthly totals of hours of sunshine as recorded by a Marvin sunshine recorder (15). These are of particular interest in this study of atmometer evaporation, since they give a chance to make a comparison

13. Briggs, L. J., and H. L. Shantz. 1919. Hourly transpiration rate on clear days as determined by cyclic environmental factors. Jour. Agr. Res. 5: 588-649.

14. Wilson, J. D., and B. E. Livingston. 1937. Lag in water absorption by plants in water culture with respect to changes in wind. Plant Physiol. 12: 185-150.

15. Marvin, C. F. 1928. Instructions for the care and management of electrical sunshine recorders. U. S. Weather Bureau Cir. G., Instrument Div., W. B. 802.

between sunlight duration and intensity, as measured by the difference in evaporation between the black and white atmometers (5). The Marvin recorder measures duration only, and intensity is a factor in its operation only in so far as a certain minimum is required to start the recorder and to continue the record. The value of an hour of sunshine in terms of whatever heat units it is measured [usually in gram calories per square centimeter per hour (16)] varies widely at different times of the day and year and on partly cloudy and clear days. The B—W values vary in the same way and for the same reasons when they are recorded hourly. A study of the variations and their relation to those in sunshine intensity and duration will be the subject of a later paper.

There is a fair degree of correlation between the 5-month totals of sunshine hours and evaporation from the black atmometer (table 1), and months of high evaporation usually are also high in total hours of sunshine. This is to be expected, since clear skies and dry weather go with both. The 10-year averages show July to be the month of highest average evaporation and hours of sunshine. September has the lowest values in both these types of data for the 5 months under consideration. June is in second position in each respect, but May is above August in sunshine hours and below it in evaporation. July 1932 was the sunniest month of the 50 observed, but the greatest evaporation was in July 1930, when the effect of high temperatures and low humidities overshadowed that of radiation alone. September 1933 was lowest in sunshine hours, but the same month in 1929 was considerably lower in evaporation, although only slightly higher in sunshine.

TABLE 10.—Average monthly values of an hour of sunshine in terms of cubic centimeters of water evaporated

Obtained by dividing the B—W value for a given month by the corresponding hours of sunshine (B—W/S)

Month	1928	1929	1930	1931	1932	1933	1934	1935	1936	1937	10-year av.
	Cc.	Cc.	Cc.	Cc.	Cc.	Cc.	Cc.	Cc.	Cc.	Cc.	Cc.
May.....	1.19	1.22	1.16	1.24	1.30	1.19	1.07	1.12	1.10	1.13	1.17
June.....	1.45	1.36	1.27	1.31	1.34	1.25	1.24	1.30	1.16	1.21	1.30
July.....	1.24	1.30	1.49	1.40	1.20	1.26	1.25	1.20	1.13	1.20	1.27
August.....	1.34	1.29	1.13	1.40	1.25	1.27	1.21	1.30	1.14	1.11	1.24
September.	1.12	1.27	1.02	1.26	1.12	1.36	1.17	1.27	1.19	1.10	1.19
5-month averages	1.27	1.29	1.23	1.32	1.29	1.26	1.28	1.24	1.17	1.17	1.25

The data of table 10 show the average values of an hour of sunshine (as recorded by the Marvin recorder in table 9) in terms of cubic centimeters of water lost from the black atmometer in excess of that lost from the white one (B—W values of table 3). Since it requires approximately 580 gram calories of energy to vaporize 1 cubic centimeter of water at 22° C. and the atmometer has a cross-sectional area of about 20 square centimeters, with about 80 per cent of the total radiant energy absorbed by that half of the sphere which is toward the sun, the values of table 10 can be converted into gram calories per square centimeter per hour by multiplying by the factor 23.2. Thus, if the average July day of 11.7 hours of sunshine has a B—W value of 15.13 cubic centimeters, this would represent a daily average value of 351 gram calories per square

16. Briggs, L. J., and H. L. Shantz. 1919. Daily transpiration during the normal growth period and its correlation with the weather. Jour. Agr. Res. 7: 155-212.

centimeter per day, which is probably about 75 per cent of the true value of the radiant energy factor at Wooster (17). This indicates that the B—W values probably represent only about 75 per cent of the total quantity of radiant energy which the atmometers intercept. Most of this deficiency is accounted for by the fact that the black instrument reflects approximately 5 per cent of the radiant energy striking it and the white absorbs as much as 15 per cent after it is slightly weather soiled. There is, therefore, a total error of 20 per cent.

The 5-month average values for the 10 years are comparatively uniform, as one would expect. The high average for 1931 is rather difficult to explain, since the B—W value for that year in table 3 is not especially large and the number of hours of sunshine, as listed in table 9, is only slightly below the average. The low value for 1936 seems to be due to a low B—W value for that year; whereas the total number of sunshine hours was slightly above the 10-year average. The average hour of sunshine is most effective in causing evaporation (drying) in June, closely followed by that of July and August. September is slightly higher than May, but this is possibly more apparent than real because of the comparatively small number of years (10 years) involved in the averages. It should be noted that the B—W/S value is usually well above the average during months which are low in total hours of sunshine. This situation is largely brought about by the fact that on many of the days which are just cloudy enough that the Marvin recorder indicates little or no sunshine, the black atmometer may absorb enough radiant energy that its corrected water loss exceeds that of the white instrument by from 1 to 5 cubic centimeters per day. A number of such cloudy days occurring in a cloudy month boost the B—W total with little addition to the total hours of sunshine. As a result, the B—W/S value will be high for that month, as it was in June 1928. On the other hand, months which are well above the average in total sunshine hours may also show above the average B—W/S values, since total radiant energy values tend to build up and continue high in dry periods with many days of few clouds and clear atmosphere. July 1930, which had the highest average hourly B—W/S value of the 50-month period was such a month. August 1928 and September 1935 were other similar months.

In table 11 are shown the average number of cubic centimeters lost from the black atmometer for each inch of water lost from the standard evaporation pan each month. Again the 7-year data are used because the pan and atmometers were not in the same location for the first 3 years of the 10-year period. The values of table 11 are of particular value in a study of atmometer evaporation, since they give a value to a conversion factor which may be used in converting corrected losses from the black atmometer into inches of evaporation from the standard pan and these values may then in turn be used to determine the evaporation-rainfall ratio. The conversion factor for black atmometers may be assumed to be 264 on the basis of a 7-year average, and that for the white atmometer is 186 (table 16). This value varies somewhat from year to year and month to month, but it seems likely that it will continue to fall close to 260 and 180 for the black and white atmometers, respectively, as more data are collected. The value of this factor seems to be more closely correlated with temperature values than with those of any other one factor. During months with high mean temperatures the conversion factor usually has a lower than average value, and vice versa. This indicates that the standard pan responds

17. Kimball, H. H. 1927. Measurement of solar radiation intensity and determination of its depletion by the atmosphere with bibliography of pyreheliometer measurements. *Mo. Weather Rev.* 55: 155-169.

more to temperature variations (and high radiant energy values due to intense sunlight) than does the atmometer, as has been mentioned before (4). In line with this, the July value is lowest and that for September is the highest. In other words, the atmometer loses fewer cubic centimeters of water while the standard pan is losing an inch of water in July than is the case in September. May and August ratios are similar, and the ratio for June is only slightly more than that for July. The various average monthly values are in the same relative order of magnitude for the white atmometers, but the complete data are not given here.

**TABLE 11.—Cubic centimeters of corrected loss from a standardized black spherical atmometer per inch of water lost from a standard United States Weather Bureau Evaporation pan at Wooster, Ohio (B/P or conversion factor)**

Month	1928	1929	1930	1931	1932	1933	1934	1935	1936	1937	7-year av.
	<i>Cc.</i>	<i>Cc.</i>	<i>Cc.</i>	<i>Cc.</i>	<i>Cc.</i>	<i>Cc.</i>	<i>Cc.</i>	<i>Cc.</i>	<i>Cc.</i>	<i>Cc.</i>	<i>Cc.</i>
May .....	368	272	266	256	282	249	295	225	278	277	266
June .....	309	296	255	236	292	265	241	241	256	252	255
July .....	283	257	249	235	254	279	250	223	258	243	249
August .....	276	245	264	250	303	279	246	241	259	267	264
September ..	403	294	286	274	354	285	245	290	279	276	286
5-month averages	328	273	264	250	297	271	255	244	266	263	264*

\*The corresponding conversion factor for the white atmometer is 186.

As mentioned previously, the data for table 12 present the monthly evaporation-rainfall ratios for the 10-year period. These were calculated from the black atmometer data by using the 7-year averages to fix the value for the conversion factor (table 11) for each month. Most of the significant features of these data were discussed earlier in this paper, and other features will be considered in another to be published later. It may be noted here, however, that the value of this ratio varied during the 10-year period from a low of 0.41 in August of 1935 (rainfall 9.53 inches and evaporation 3.94 inches) to a high of 15.63 in May of 1934 (rainfall 0.43 inch and evaporation 6.72 inches). The 5-month value was lowest in the wet year of 1935 and highest in the dry year of 1930.

**TABLE 12.—Monthly evaporation-rainfall ratio values at Wooster, Ohio**

Month	1928	1929	1930	1931	1932	1933	1934	1935	1936	1937	10-year monthly av.
May .....	3.23	0.82	3.43	0.93	2.59	0.83	15.63	0.97	2.02	1.21	1.61
June .....	.75	1.23	2.34	1.36	1.70	4.10	1.52	.91	3.45	.88	1.49
July .....	1.41	.76	4.68	2.16	2.09	4.31	2.51	.54	1.20	1.59	1.53
August .....	1.12	3.79	2.29	1.05	3.00	1.43	1.19	.41	.87	1.43	1.22
September ..	6.76	1.99	1.72	1.04	2.44	.85	.55	1.90	1.51	1.38	1.38
5-month averages	1.54	1.18	2.67	1.26	2.25	1.66	1.57	.71	1.48	1.24	1.43

In table 13 the percentage of the total evaporation from the black atmometer (B) which may be ascribed to the absorption of radiant energy (B—W) is shown for each month. The average amount due to this factor for the 50 months was 29.2 per cent with a minimum value of 20.2 per cent in August of

1930 and a maximum of 39.4 per cent in June of 1928. As might be expected, the role played by radiation was smallest (24 per cent) in the year of highest evaporation (1930) and greatest (33.5 per cent) with the lowest evaporation total (1937). When the effect of radiation on evaporation is compared with the effect due to all other factors (W values of table 2) in table 14, it is seen that radiation also had the smallest relative percentage value in the dry year of 1930 (31.5 per cent) and the greatest in 1937 (50.4 per cent). Thus, even in 1930, when many of the factors which influence the rate of water loss combined to give evaporation a high value, losses due to radiation were nearly one-third as large as those due to all other factors, and in a wet year they reached the high value of 50.4 per cent. On certain calm days of high relative humidity, rather low temperature, and a few bright cumulus clouds in the sky, radiation may account for as much as 47 per cent of the total evaporation, and this amount may be 90 per cent as great as that due to all other factors combined (W values). On the other hand, even on sunny days, the radiation effect has been responsible for as little as 12 per cent of the total evaporation loss (B), and the B—W value was then only 15 per cent as great as the evaporation resulting from the effect of all other factors (W). Many of these relationships will be discussed in more detail in a future paper in this publication.

**TABLE 13.—Percentage of losses from black atmometer which were due to the sunshine (radiation) factor at Wooster, Ohio (B—W/B)**

Month	1928	1929	1930	1931	1932	1933	1934	1935	1936	1937	10-year av.
	<i>Pct.</i>	<i>Pct.</i>	<i>Pct.</i>	<i>Pct.</i>	<i>Pct.</i>	<i>Pct.</i>	<i>Pct.</i>	<i>Pct.</i>	<i>Pct.</i>	<i>Pct.</i>	<i>Pct.</i>
May .....	27.9	33.1	24.6	31.1	33.5	31.5	21.4	26.6	28.4	30.3	28.4
June .....	39.4	33.1	25.3	37.3	31.3	27.9	27.1	29.7	24.8	35.3	30.3
July .....	35.6	34.3	27.6	31.2	31.5	24.8	31.0	32.4	24.5	35.6	30.3
August .....	33.0	30.5	20.2	28.5	26.4	27.7	30.0	33.8	25.6	35.5	28.6
September ..	23.6	30.3	20.4	31.7	24.6	28.7	31.2	33.9	26.0	30.6	27.7
5-month averages	31.5	32.3	24.0	31.9	29.5	27.7	27.6	31.3	25.8	33.5	29.2

**TABLE 14.—Comparative influence of sunshine (radiation) factor on evaporation with reference to that of all other factors**

As measured by the white atmometer at Wooster, Ohio (B—W/W)

Month	1928	1929	1930	1931	1932	1933	1934	1935	1936	1937	10-year av.
	<i>Pct.</i>	<i>Pct.</i>	<i>Pct.</i>	<i>Pct.</i>	<i>Pct.</i>	<i>Pct.</i>	<i>Pct.</i>	<i>Pct.</i>	<i>Pct.</i>	<i>Pct.</i>	<i>Pct.</i>
May .....	38.8	49.4	32.7	45.2	50.3	46.0	27.2	36.2	39.7	43.4	39.6
June .....	65.1	49.5	33.9	59.5	45.5	38.7	37.3	42.2	32.9	54.6	43.5
July .....	55.4	52.2	38.1	45.3	45.9	33.0	44.7	47.9	32.4	55.2	43.5
August .....	49.2	43.1	25.3	39.9	35.9	38.4	42.9	51.0	34.4	55.1	40.1
September ..	30.9	43.5	25.6	46.3	32.6	40.3	45.3	51.3	35.1	44.0	38.4
5-month averages	45.9	47.8	31.5	46.8	41.8	38.3	38.1	45.5	34.7	50.4	41.2

In table 15 the relative monthly values of the 10-year averages of the values of most of the various environmental factors which regulate evaporation, as well as those for evaporation itself, are summarized. In evaluating these monthly averages, that for July is taken as 100 and the others are all stated as percentages of that amount. In some cases, if the value for July was lower

than that for the other months concerned, the reciprocals were used in making some of the comparisons used in the text. This is true of relative humidity, where a low value is conducive to a higher evaporation rate than is a high one, and it happens that July had the lowest value in this instance. Most of the values given in table 15 have been discussed elsewhere in the text and will not be considered here.

TABLE 15.—Relative monthly values of 10-year averages for various factors when those for July are taken as 100

Month	Black atmo- meter (B)	White atmo- meter (W)	Black minus white (B-W)	Stand- ard pan (P)	Rain- fall (R)	Mean tem- pera- ture	Rela- tive humid- ity at noon, Colum- bus	Wind veloc- ity*	Sun- shine dura- tion (S)	B-W value of an hour of sun- shine B-W/S	Con- version factor B/P*
May.....	83	85	77	75	73	80	104	153	85	92	107
June.....	90	90	90	88	91	93	106	127	90	102	102
July.....	100	100	100	100	100	100	100	100	100	100	100
August....	84	86	80	81	99	95	110	113	80	98	106
September	71	74	65	61	68	87	110	128	71	94	115

\* 7-year averages.

Table 16 is a summary of the 10-year monthly averages for much of the data given in the first 14 tables, together with the 10-year averages or totals, as the case may be, and the maximum and minimum monthly values which occurred during the 50 months when evaporation data were collected.

## SUMMARY

In 1926, a State-wide survey of evaporation was begun in Ohio. One of the stations was located at Wooster and in 1928 it was equipped with both black and white Livingston standardized spherical atmometers. This made it possible to measure the effect of sunshine (radiant energy) on evaporation, as separate from the influence of other contributory factors. The data have been continued as daily readings from May 1 to September 30 each year since. Data relative to temperature, wind velocity, rainfall, open pan evaporation, and sunshine have also been recorded from instruments located close to the atmometers. All these data have been of considerable ecological interest because of the drouths which have prevailed at intervals during at least 4 of the 10 summers from 1928 to 1937.

The average (10-year) monthly values from the black and the white atmometers and the standard evaporation pan are in the same order of magnitude for the 5-month period. July values are largest in each instance, followed by those of June, August, May, and September in decreasing order. The values for none of the contributory factors affecting evaporation are in this order, and this is an indication that none of them alone, even that of radiation, which is the most influential of the group, determines what the evaporation rate for a period as extensive as a month will be, but that it is only their combined effect which does this.

The effect of radiant energy (sunshine, expressed here as B—W) was responsible for about 29 per cent of the total water loss from the black atmometer over the 10-year (50-month) period. This was 41 per cent as great as the evaporation from the white atmometer, which represents the loss due to

TABLE 16.—Monthly averages for a 10-year period (1928-1937) of evaporation, rainfall, temperature, relative humidity, wind velocity, and sunlight values, together with maximum and minimum values for any month of the 50 months included, at Wooster, Ohio

Month	Evaporation values			Rainfall values			Tem- pera- ture values (mean)	Relative humid- ity (noon at Colum- bus)	Wind veloc- ities (3-foot level)*	Hours of sun- shine (S)	Sunshine values			Atmometer loss equivalent to 1 inch of evapora- tion from the standard pan		
	Atmometers		Stand- ard pan (P)	Rain- fall (R)	Evaporation- rainfall ratios						Value of 1 hour of sunshine in cubic centime- ters of evapora- tion $\frac{B-W}{S}$	Part of total loss from black atmometer due to radiation effect $\frac{B-W}{B}$	Compari- son of radi- ation ef- fect with that of all other factors $\frac{B-W}{W}$	$\frac{B}{P}$	$\frac{W}{P}$	*
	Black (B)	White (W)			$\frac{B}{R}$	$\frac{Stand-ardpanP}{R}$										
			Cc.	In.							In.	°F.	Pct.	Mi. per hr.	Hr.	Cc.
May .....	1,279	916	4.62	2.99	1.61	1.56	59.1	50	3.30	308	363	1.17	28.4	39.6	266	191
June .....	1,398	974	5.40	3.69	1.49	1.47	68.4	51	2.74	326	424	1.30	30.3	43.5	255	177
July .....	1,547	1,078	6.13	4.07	1.51	1.51	73.6	48	2.15	363	469	1.27	30.3	43.5	249	176
August .....	1,305	931	4.98	4.04	1.22	1.25	70.1	53	2.42	291	373	1.24	28.6	40.1	264	185
September .....	1,106	800	3.73	2.78	1.38	1.35	63.9	53	2.75	257	307	1.19	27.7	38.4	286	201
Average or total ..	6,635	4,699	24.85	17.57	1.43	1.42	67.0	51.0	2.68	1,545	1,936	1.25	29.2	41.2	264	186
Maximum ..	1,992	1,442	8.03	9.53	15.63	14.09	75.6	62	3.90	383	550	1.49	39.4	65.1	354	308
Minimum ..	940	596	3.12	.43	.41	.46	54.2	38	1.18	221	254	1.02	20.4	25.6	223	148

all other factors contributory to evaporation except that of radiant energy. This is true, since the white instrument reflects most of this energy; whereas the black one absorbs it. B—W makes up the smallest portion of the evaporation total (24 per cent) in the year of highest evaporation (1930) and the largest portion (33.5 per cent) in the year of lowest evaporation (1937). In 1937, B—W had a value slightly more than half as great as W, and on certain cool days with a few bright clouds in the sky, B—W may be as much as 47 per cent of B and 90 per cent as great as W.

Evaporation was above the average for the 10-year period in 1930, 1932, 1933, 1934, and 1936, and drouths of varying degrees of severity occurred in each of these years, as well as in 1928 and 1929. The drouth of 1930 was most severe. Crops did not suffer as much in 1936 at Wooster, owing to several good rains at well-spaced intervals, as they did in many other parts of Ohio and the United States. Evaporation-rainfall ratio values for each of the 50 months of the 10-year period under observation indicate that rainfall exceeded evaporation in only 13 of the 50 months; whereas evaporation was in excess of rainfall by at least 50 per cent in 24 of the 50 months and was at least twice as great in 18 of them. Just what constitutes a drouth is difficult to determine, but if "a drouth is considered to exist whenever the rainfall for a period of 21 days or longer is but 30 per cent of the average for the time and place" is accepted as a good definition, then 12 drouths occurred in this 10-year period from 1928 to 1937. Those falling in May and June were particularly injurious to oats and early garden crops; those in July and early August reduced corn yields; and those occurring in late August and September were of least economic importance, affecting chiefly the seeding of wheat.

The average monthly losses from the standard pan show a greater variation between the maximum value of July and the smaller ones of May and September than do those from either the black or white atmometers. This greater variation seems to indicate that the pan is more influenced by variations in the radiant energy and temperature factors than is the atmometer. This is well shown by the fact that the conversion factors for use in transposing black atmometer values (recorded in cubic centimeters) into inches of evaporation, to correspond with those from the standard pan, are smallest for July, a month of high temperatures and radiant energy values, and greatest for September, a month when both these factors are much less intense. These monthly variations for the pan losses correspond most closely to those for sunshine duration, followed in turn by those for temperature, relative humidity, and wind. Correlation between the evaporation values for the atmometers is also greatest with those for sunshine (and, of course, B—W, which represents the radiant energy factor). The monthly averages for the atmometer losses also vary in much the same order as do those for mean temperature but show scant correlation with those representing the average hourly wind velocity values.

The average value of an hour of sunshine in terms of water evaporated from a black atmometer ( $\frac{B-W}{S}$ ) was largest in June (1.3 cubic centimeters), followed by July, August, September, and May, in that order.

# THE EUROPEAN CORN BORER AND CORN HYBRIDS

L. L. HUBER

For the second year in succession the corn borer has been the cause of appreciable commercial damage in certain areas of Ohio. Naturally, the problem of control has become a matter of considerable concern. The purpose of this article is to describe and identify those areas which appear to be most favorable to the corn borer and to discuss briefly the principles which underlie present recommendations for control.



Fig. 1.—Area which was formerly a lake bed, known as swamplands

It is on the well-drained, dark-colored soils of this old lake bed that the corn borer has become most abundant.

asked, What measures seem to offer greatest promise of control? It should be pointed out in the beginning that the best known controls are not expected to do more than keep the borer population within reasonable limits. For example, a stalk infestation as high as 25 per cent is not one to cause much concern. Thousands of acres of corn in Ohio have had such infestations during the past 10 years with little effect on yield.

Fifteen years of investigations have shown that the avoidance of abnormally early planting on well-drained, fertile soil and the use of resistant and tolerant strains of corn are the best defense against the corn borer. These two measures are relatively effective and can be applied individually. Fundamentally they are preventive measures. If they are to be used most effectively, however, an understanding of the principles underlying them is necessary. Two factors are involved: (a) Moths deposit more eggs on tall than on short

On the map of Ohio, figure 1, is indicated that part of the State which was once the bed of an old lake. In the early days, much of this area was known as swampland on which swamp white oak, ash, and elm were dominant species. Beech and maple were found on the better-drained sites within the general area, as well as on most of the bordering territory. It is on the well-drained, dark-colored soils of this old lake bed that the corn borer has become most abundant. There are, however, many smaller areas outside the old lake bed which are favorable corn borer habitats. Fewer borers are found in corn grown on the light-colored soils, or where beech and maple were once the dominant trees.

The region of greatest borer population having been indicated, the question may now be

corn. The chart, figure 2, shows the relative proportion of moths that may be expected to lay eggs on corn of different heights. (b) A higher percentage of young borers develops into mature borers on the taller and earlier corn. The shorter and more immature plants provide less protection for the young borers and also a less satisfactory supply of food.

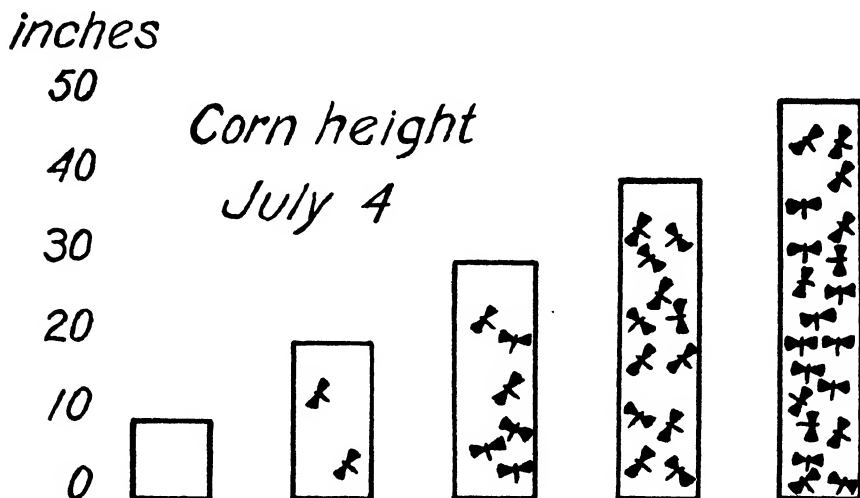


Fig. 2.—The relation between the height of corn and its attractiveness to moths

The tallest corn receives the most eggs, and the highest larval survival is on the earliest corn.

A consideration of these two facts then, namely, that the most eggs are deposited on the tallest corn and that the larval survival is also highest on the tallest, which is generally the earliest corn, goes far in explaining why the borer is most abundant in the best corn growing areas. Indeed, seasonal fluctuations in corn borer populations are often explained by these two facts. For example, weather conditions which compel late planting or which retard growth of corn planted on a normal date automatically reduce borer populations; whereas weather which encourages early planting or accelerates corn growth beyond normal, other factors being equal, tends to increase population. In early seasons growers on the best farms in the corn borer area should consider the advisability of delayed planting. After a thorough consideration of the level of borer population within a given community and the relative productiveness of the land, growers should aim at a date which, on the one hand, promises reasonable protection from commercial losses due to the borer and, on the other hand, possible losses due to early frosts in the fall.

The second suggested method of control involves the use of selected strains. In general, this method is recommended for most farms within the general corn borer territory, particularly those with light-colored soils or poorly drained dark soils. In part, the principles are identical with those involved in later planting. Just as borer survival is higher on early than on late planted corn, it is also higher on early than on late season strains. For example, Ia. 939 and Ohio

C14 (figure 3), planted side by side, received approximately equal numbers of eggs, yet Ohio C14 had only one-half as many borers per stalk at the end of the season. Largely because Ohio C14 is a later season strain than Ia. 939, borer survival is less. It is this difference in borers per stalk that most growers and seedsmen have in mind when they say that a certain strain is resistant to the corn borer. It is a type of resistance associated with seasonal maturity. Resistance other than that accounted for through seasonal maturity is present in certain strains, but in general it is not of important commercial consequence.

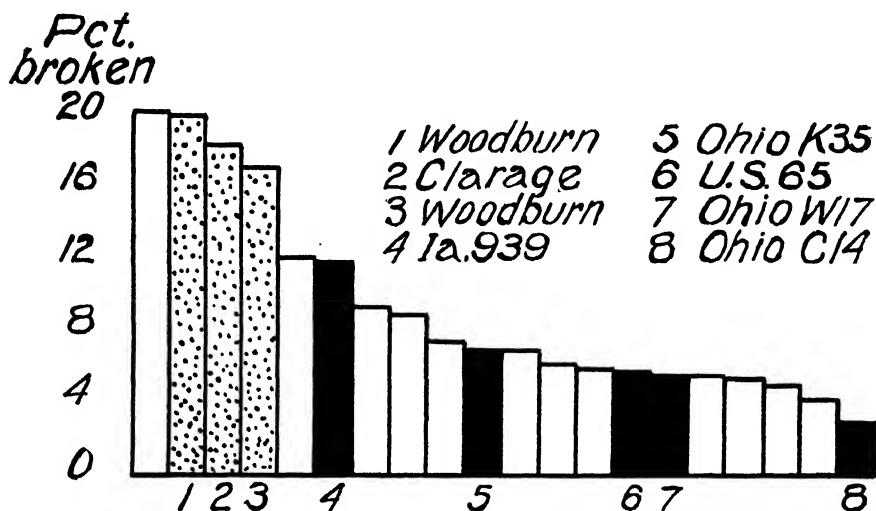


Fig. 3.—Percentage of stalks broken below the ear in a cooperative corn hybrid performance test in Hardin County, 1938<sup>1</sup>

A severe windstorm occurred August 12.

Strains differ also in their tolerance to the borer. As noted in figure 3, stalk breakage is much greater in Clarage and Woodburn than in Ia. 939, Ohio K35, U. S. 65, Ohio W17, and Ohio C14, all of which are grown in the corn borer area. Moreover, breakage in Ohio C14 is only 25 per cent as great as in Ia. 939.

On the best farm lands in the favorable corn borer areas, delayed planting and the so-called resistant and tolerant strains may be used jointly. For example, suppose that a grower has two fields to be planted to corn. Field No. 1 is light-colored soil and field No. 2 is dark-colored soil. If some strain like Ia. 939 were to be planted in both fields, it would be the wiser plan to plant field No. 1 first; field No. 2 should be delayed. If the grower contemplated planting both Ia. 939 and some strain like Ohio C14,<sup>2</sup> it would be wise to plant field No. 1, with the light-colored soil, to Ia. 939 and field No. 2 to Ohio C14. Because Ohio C14 is a later maturing strain, no appreciable delay in planting would be necessary.

Any grower who through past experience with the corn borer suspects further losses due to this insect would do well to select his strains carefully and plan his planting in accordance with the general principles outlined.

<sup>1</sup>This work was done in cooperation with G. H. Stringfield, Department of Agronomy of the Ohio Agricultural Experiment Station and Division of Cereal Crops and Diseases, Bureau of Plant Industry, U. S. Department of Agriculture; Ohio Seed Growers and Seed Association; and the Agricultural Extension Service, The Ohio State University.

<sup>2</sup>Ohio C14 is a new hybrid. Seed will not be available for general plantings until 1940.

# THE CARE OF LAYERS IN BATTERIES

D. C. KENNARD AND V. D. CHAMBERLIN

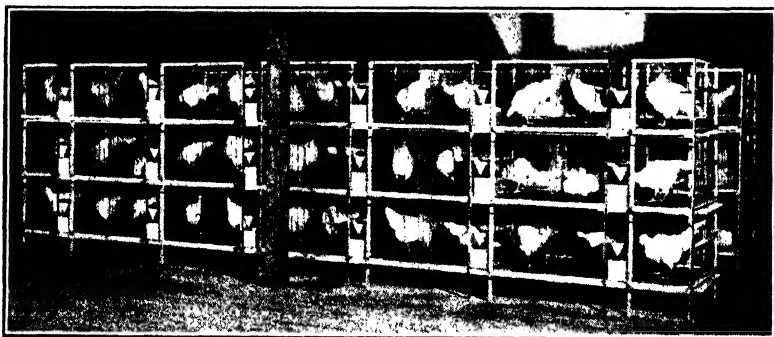
Poultrymen contemplating the use of laying batteries should consider the advisability of beginning on a small scale first to see whether batteries prove a failure or a success under their particular conditions of operation. Moreover, a modest beginning permits the poultryman to learn a primary essential—whether or not he likes working with layers in batteries. Some do and succeed; others do not and fail.

If a poultryman likes working with layers in batteries, and if he can meet the special requirements, such as weekly culling, a supply of suitable birds always available for replacements, adequate housing for batteries, proper ventilation for the battery room, and numerous other requisites, he should be able to succeed if too large-scale operations are not undertaken.

The operation of laying batteries on a large scale is attended by many unforeseen difficulties. The only reasonably safe approach to large-scale operation is starting and succeeding on a small scale first. After the first essential accomplishment, the next would be gradually to increase the capacity over a period of years, largely by means of self-capitalization rather than by the introduction of outside capital. In this way the large-scale operation of batteries for layers could be made a sound business venture.

## FEEDING AND WATERING LAYERS IN BATTERIES

It might seem that the feeding and watering of layers in batteries would be simple matters, but they have not been. Most problems of this kind become simple after a long-time experience of trial and error. Such has been the evolution of feeding and watering equipment, as well as methods of feeding layers in batteries during the past 10 years.



**Fig. 1.—The first commercial installation of laying batteries at the Ohio Station, made in 1931**

Feed and water troughs were first placed on the batteries crosswise so that each trough served four layers, as shown in figure 1. These were quite satisfactory from the point of feeding, but were otherwise inconvenient and occupied too much valuable battery space. They were, therefore, abandoned.

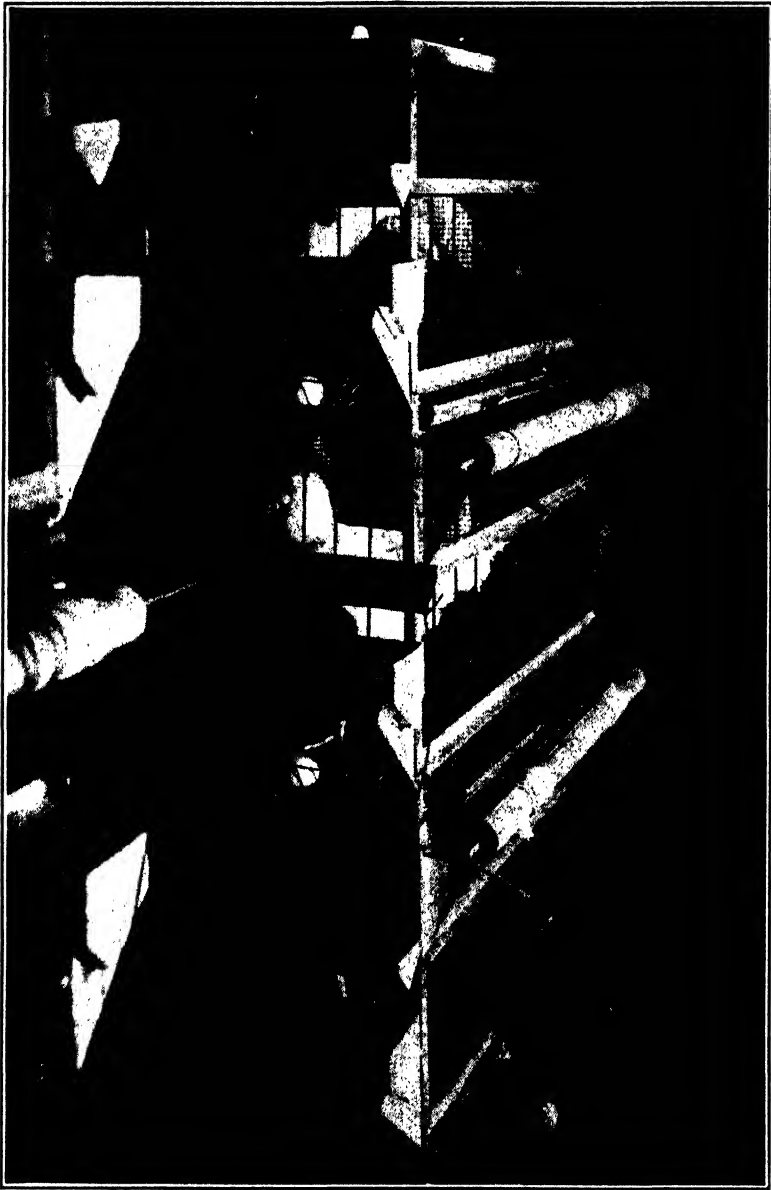


Fig. 2.—End view of feeding and watering equipment showing drip water supply at top

The water flows through three tiers of water troughs. Any water surplus finally flows down the drainage wire from the lower trough to the floor and passes through a  $\frac{1}{2}$  x  $\frac{1}{2}$ -inch drainage channel in the cement floor to a drain.

### FEEDING EQUIPMENT

Abandonment of these first feeders was followed by individual feeders in front of the cages; in some instances these individual feeders were divided into two or three separate compartments for whole grain, mash, and shells. The individual compartment feeders were not satisfactory. The next development was front feeders, with or without compartments, to serve 2 or 3 hens. Now, after 10 years of trial and error and experience with all types of feeders for laying batteries, satisfactory feeding equipment has been developed.

Feed troughs should be of no greater capacity than necessary to prevent wastage of feed. Such a trough is shown in figure 2. The width and greatest depth of the feeder are both 4 inches. The V-shaped bottom with the short side toward the battery makes the feed easily accessible. The other dimensions are: vertical side next to battery,  $2\frac{1}{2}$  inches; short side of V-shaped bottom next to battery,  $2\frac{1}{4}$  inches, outer side of V-shaped bottom,  $3\frac{1}{4}$  inches; and outer vertical side of trough,  $2\frac{1}{4}$  inches.

Lips to prevent wastage of feed extend inward one-half inch with a  $\frac{1}{8}$ -inch fold on the underside to make a smooth edge. The feeders are made of 26-gauge, galvanized sheet metal. Brackets support the feeders so that the inner top edge of the feeder is 7 inches above the wire floor.

The feed trough should be without partitions or compartments and should serve 4 to 10 layers. The length of the feed trough in this type of equipment is limited to that which can be handled with reasonable convenience, since it is generally necessary to remove the feed trough when a layer is removed or replaced.

### WATERING EQUIPMENT

At the Ohio Station watering equipment inside and outside the batteries has been tried. This equipment has included cups, wire loop drip waterers, and troughs, with and without drip water supply. The watering equipment now being used consists of galvanized sheet metal troughs which extend across the front of each tier of cages directly above the feeders.

The water comes by means of a drip from water under pressure or from a supply tank into the closed end of the top water trough and flows through the three tiers of troughs shown in figure 2. Any surplus water finally flows down the drainage wire from the lower trough to the floor and passes through a drainage channel (about one-half inch wide and one-half inch deep) in the cement floor to the floor drain.

The water troughs are supported by adjustable brackets, and there are approximately 3 inches of clearance between the bottom of the water trough and the top of the feed trough. The water troughs are carefully leveled by means of the adjustable brackets to give the desired depth of water (one-fourth to three-eighths of an inch). The water trough is made of 26-gauge, galvanized sheet metal and has a V-shaped bottom. The greatest vertical depth from top to bottom is  $2\frac{1}{4}$  inches; the vertical sides are three-fourths of an inch high; and the sides of the V-shaped bottom are 2 inches. The top edges are made with  $\frac{1}{8}$ -inch folds on the outside to give a smooth edge and added rigidity. Each trough is closed on one end (drip water supply end), but the drainage, or overflow, end is left open except for a small, sloping dam made by soldering in a triangular piece of galvanized sheet metal to retain a  $\frac{1}{4}$ - to  $\frac{3}{8}$ -inch depth of water, as shown in figure 3. The dam slopes upward one-half to three-fourths

of an inch from the inner point at the bottom, to facilitate cleaning. The outer edge of the dam extends to within 1 inch of the end of the trough. A piece of No. 11 gauge, galvanized wire is soldered into the V bottom at the end of the

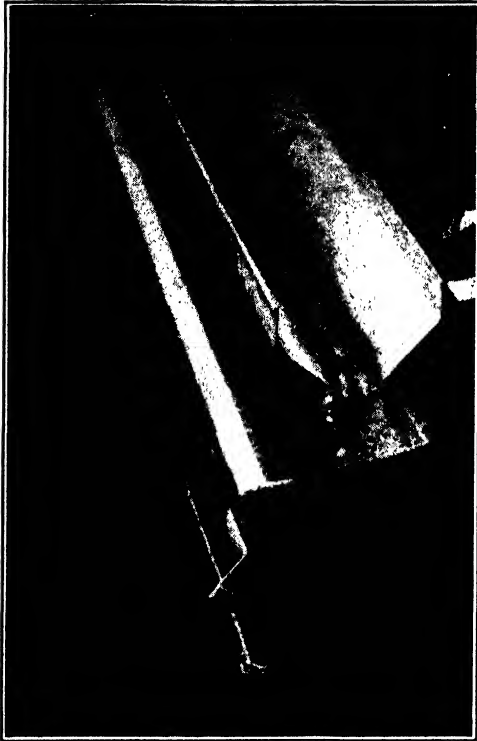


Fig. 3.—Open end of water trough showing the sloping dam which maintains the water level at a depth of one-fourth to three-eighths of an inch, and the wire extension to which the drainage wire is attached

trough just outside the dam and extends 1 inch beyond the end of the trough. This extension is bent upward so that the drainage wire to the trough below can be attached. The drainage wire which carries the water from one trough to another consists of a No. 11 gauge, galvanized wire with a narrow loop on the top end which hooks over the wire extending from the drainage end of the water trough above. The drainage wire extends to within one-fourth of an inch of the bottom of the lower trough. The lower end of the wire is bent slightly toward the end of the trough to keep the wire about one-half inch from the top end so that all the water will be carried into the trough. The ends of the water troughs extend 1 or 2 inches beyond the ends of the feed troughs so that the drainage wires can pass from one water trough to the other below without contacting the ends of feed troughs. Otherwise, some of the water might drop into the feed trough. When the feed and water troughs are of the same length,

the drainage wires can be curved outward in order to avoid contact with the ends of the feed troughs, but this is not altogether satisfactory.

The type of equipment described is intended primarily for modernizing feeding and watering equipment of old laying battery installations, such as that in use at the Station. Some of the new designs of laying batteries are already provided with satisfactory feeding and watering equipment.

#### RATIONS FOR LAYERS IN BATTERIES

Tests carried on at the Station indicate that coarse all-mash or whole grain and mash rations can be used with equally satisfactory results. A single feed mixture is convenient and requires less skill to use. The whole oats-mash mixture now being used by the Station is composed of the following ingredients:

	Per cent*
Yellow corn, coarsely ground .....	20
Whole oats .....	20
Ground oats, medium fine .....	10
Wheat middlings .....	20
Wheat bran, coarse .....	10
Meat scraps, 50 to 55 per cent protein .....	7
Soybean oil meal .....	2.5
Dried skimmilk .....	5
Alfalfa leaf meal (dehydrated) .....	5
Salt .....	0.5
Cod-liver oil (85 units of vitamin D) .....	1
Oyster shells .....	5
Granite grit .....	2

\* Not including cod-liver oil, oyster shells, and granite grit.

This appears to be the best ration for layers in batteries yet employed. It is an all-inclusive feed mixture, even including oyster shells and grit.

#### METHODS OF FEEDING

Fresh feed is given morning and evening in the amount that will about be consumed before the next feeding period. The feed is redistributed before the birds midforenoon and midafternoon, which practically amounts to feeding four times daily. The use of continuous feeders (without partitions or compartments) each accommodating 4 to 10 layers and the redistribution of the feed are important in the feeding of layers in individual batteries. No two hens eat the same amount of feed, and the individual consumption of whole oats, oyster shells, and grit varies greatly. This individual variation has presented one of the most difficult problems in the feeding of layers in individual cages. The continuous feed troughs and the midforenoon and midafternoon redistribution of the feed have proved the most satisfactory solution of that problem.

A layer in high egg production may have all the feed within reach consumed by midforenoon or midafternoon, and with redistribution of the feed she gets a chance to share the surplus feed, whole oats, shells, or grit not consumed by her neighbors. For example, the layers in the highest rate of egg production probably need, and certainly will often consume, more oyster shells than 5 per cent of the total feed. With redistribution of the feed twice daily the best layers get a chance at the shells not needed by other birds. It is a comparatively simple matter to feed 4 to 10 layers as a unit; whereas catering to the individual requirements of birds, as is necessary when individual feeders are used, becomes needlessly difficult and time consuming.

#### LIVABILITY AND EGG PRODUCTION

Layers in batteries have rendered a favorable account of themselves in both livability and egg production in all the experiments conducted by this Station since 1924. During the past 5 years pullet layers in batteries have been tested in direct comparison with pullets in floor pens. Since livability of pullet layers has of late years become the question of greatest concern, how did the layers in batteries behave in this respect as compared to similar pullets in floor pens? Here the battery layers won a high score. In only 2 of the 25 tests did the loss of pullets in the battery groups exceed that in the floor pens. The average rate

of mortality (including culls) of the layers in batteries in the 25 tests was 37 per cent; that of similar pullets in floor pens was 51 per cent. There was little difference in egg production. In 13 of the 25 tests the pullets in batteries laid more eggs than the pullets in floor pens. The average for the 25 tests was 7 eggs per bird<sup>1</sup> in favor of the pullets in batteries.

From these results it would seem that in so far as the behavior and performance of the layers in batteries are concerned, the question of success or failure with layers in batteries is largely to be determined by the caretaker, his management, and whether or not he can meet the special requirements of keeping layers in batteries.

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<sup>1</sup>Computed on the basis of the original number of pullets at the beginning of the tests.

## TAX DELINQUENT RURAL LAND UNSUITED FOR AGRICULTURE IN SOUTHEASTERN OHIO

H. E. MOORE

Rural real estate tax delinquency in Ohio can be conveniently separated into three divisions based on location and land use. First, in areas adjacent to urban centers, high tax valuations based on site value, and special assessments levied for roads, streets, sewer and water systems have caused delinquent taxes to become a serious problem. Second, in areas of relatively good agricultural land, tax delinquency rapidly increased for a decade prior to 1933 owing to heavy taxation and declining farm incomes. Better farm incomes and reduction in taxes during the past 5 years have made it possible to reduce the total outstanding delinquency in some areas of good agricultural land, and in other similar areas the outstanding delinquency has been held about constant. These facts indicate that most of the delinquent taxes on land suitable for agriculture will be paid before the land actually becomes eligible for tax sale. On the other hand, a third type of situation exists in some areas of southeastern Ohio where a substantial amount of the land is not suited to agriculture. Some of this type of land exists in all the counties covering the hill region, but the greatest concentration lies in the area from Hocking County east to the Ohio River and south to Scioto County. Tax delinquency in this region tends to become chronic. At the present time it is unknown how many acres would be eligible for sale for taxes throughout the region, although recent investigation shows that in Hocking County more than 8,500 acres and in Scioto County 35,900 acres, or 9 per cent of the total acres, have been delinquent 4 years or more.

The study now being conducted in cooperation with the Bureau of Agricultural Economics of the United States Department of Agriculture indicates that a high correlation exists in southeastern Ohio between chronic rural real estate tax delinquency and land submarginal for agricultural purposes. In this region those tracts of land not suited to agriculture are rapidly reverting to brush and timber. In this condition the land yields little or no regular annual income either for private use or to pay taxes.

**TABLE 1.—Chronically tax delinquent lands in Hocking and Scioto Counties classified according to adaptability to agricultural use**

	Hocking County			Scioto County		
	Adapted	Poorly adapted	Not adapted	Adapted	Poorly adapted	Not adapted
Number of holdings (40 acres and over) .....	6	2	54	28	29	219
Total acres.....	1,147	416	5,003	3,190	2,707	23,660
Land use:						
Cultivated, acres .....	158	18	111	1,611	489	1,140
Open idle, acres .....	147	65	1,113	562	599	2,461
Pasture, acres.....	408	268	242	431	451	1,113
Brush and woods, acres ..	434	65	3,537	585	1,168	18,946
Topography:						
Level, acres .....	150	.....	81	1,345	52	398
Rolling, acres .....	132	110	301	873	966	3,890
Rough and broken, acres ..	865	306	4,621	972	1,689	19,372
Tax valuation per acre:						
Land, dollars.....	13.61	8.94	7.21	23.58	7.50	6.12
Buildings, dollars .....	3.33	1.76	1.43	7.80	2.20	1.45
Total, dollars.....	16.94	10.70	8.64	31.38	9.70	7.57

The data in table 1 were assembled only on holdings containing 40 acres or more which have been delinquent 4 years or longer. Out of the total tax delinquent acreage classified in Hocking County, approximately 17 per cent appeared to be satisfactory for agriculture and an additional 6 per cent was poorly adapted to agricultural uses. The remaining 77 per cent of the chronically tax delinquent land was clearly submarginal for agricultural purposes. In Scioto County a similar classification indicated 11 per cent of the land to be agricultural, 9 per cent poorly adapted to agriculture, and 80 per cent definitely nonagricultural. The information assembled on land use, topography, and tax valuations in table 1 suggests in a general way the physical characteristics and value of the different classes of land which are chronically tax delinquent in these two counties.

The circumstances associated with much of the chronically tax delinquent land in southeastern Ohio point to the desirability of its acquisition for State forestry purposes whenever the various tracts of such land could be so utilized. As a matter of fact the conservation clause of the State Constitution of 1912 empowered the General Assembly to pass enabling legislation for that purpose. This has never been done. However, the continued deterioration of the land and its present uneconomical use are hastening the day when the problem must be given legislative consideration.

# INDEX NUMBERS OF PRODUCTION, PRICES, AND INCOME

J. I. FALCONER

The 1938 income to Ohio agriculture amounted to \$304,000,000. This was 13 per cent lower than the income for 1937. In December of 1938, Ohio farm products prices were 14 per cent lower than those of 1 year ago; the prices paid by farmers for commodities purchased were 5 per cent lower. During December 1938, Ohio farm prices were 81 per cent of parity.

## Trend of Ohio prices and wages, 1910-1914=100

	Wholesale prices, all commodities U. S.	Weekly earnings N. Y. State factory workers	Prices paid by farmers	Farm products prices U. S.	Ohio farm wages	Ohio farm real estate	Ohio farm products prices	Ohio cash income from sales
1913.....	102	.....	101	101	104	100	105	101
1914.....	99	100	100	101	102	102	105	108
1915.....	102	101	105	98	103	107	106	111
1916.....	125	114	124	118	113	113	121	121
1917.....	172	129	149	175	140	119	182	199
1918.....	192	160	176	202	175	131	203	240
1919.....	202	185	202	213	204	135	218	266
1920.....	225	222	201	211	236	159	212	226
1921.....	142	203	152	125	164	134	132	130
1922.....	141	197	149	132	145	124	127	130
1923.....	147	214	152	142	166	122	134	144
1924.....	143	218	152	143	165	118	133	146
1925.....	151	223	157	156	165	110	159	174
1926.....	146	229	155	145	170	105	155	177
1927.....	139	231	153	139	173	99	147	165
1928.....	141	232	155	149	169	96	154	156
1929.....	139	236	153	146	169	94	151	165
1930.....	126	226	145	126	154	90	128	137
1931.....	107	207	124	87	120	82	89	100
1932.....	95	178	107	65	92	70	63	73
1933.....	96	171	109	70	74	59	69	85
1934.....	110	182	123	90	77	63	85	98
1935.....	117	191	125	108	87	66	110	127
1936.....	118	199	124	114	100	71	118	147
1937.....	126	215	131	121	118	75	128	161
1936								
July.....	118	198	123	115	105	.....	121	189
August.....	119	202	126	124	.....	.....	131	183
September.....	119	198	127	124	.....	.....	127	169
October.....	119	202	127	121	108	.....	124	164
November.....	120	201	127	120	.....	.....	123	158
December.....	123	211	128	126	.....	.....	127	160
1937								
January.....	125	209	130	131	104	.....	128	151
February.....	126	211	132	127	.....	.....	127	141
March.....	128	218	132	128	.....	75	129	157
April.....	128	219	134	130	118	.....	134	170
May.....	127	219	134	128	.....	.....	135	164
June.....	127	220	134	124	.....	.....	134	162
July.....	128	218	133	125	123	.....	138	191
August.....	128	220	132	123	.....	.....	135	171
September.....	128	215	130	118	.....	.....	129	164
October.....	125	214	128	112	127	.....	123	157
November.....	122	205	127	107	.....	.....	116	156
December.....	119	207	126	104	.....	.....	114	142
1938								
January.....	118	201	126	102	115	.....	109	135
February.....	116	204	126	97	.....	.....	105	121
March.....	116	205	125	96	.....	74	106	130
April.....	115	204	125	94	116	.....	104	126
May.....	114	201	125	92	.....	.....	104	132
June.....	114	202	124	92	.....	.....	106	131
July.....	115	205	123	95	119	.....	106	152
August.....	114	205	122	92	.....	.....	100	133
September.....	114	214	121	95	.....	.....	102	134
October.....	113	212	121	95	119	.....	96	132
November.....	113	207	121	94	.....	.....	98	138
December.....	112	.....	120	96	.....	.....	98	137

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## Ohio Agricultural Experiment Station

WOOSTER, OHIO, U. S. A.



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Special days annually bring several thousand people to Wooster to learn what's new in agriculture, to get help from the Station's men, to hear instructive talks, and to trade ideas with fellow farmers.

**Mark these down for this summer:**

Truck Field Day (Marietta) .....	July 1
Potato Day .....	August 4
Dairy Day .....	August 11
Orchard Day .....	August 18

# SUN-COLORING APPLES

C. W. ELLENWOOD AND T. E. FOWLER

Sun-coloring apples in the orchard is not altogether a new practice. A generation ago the entire crop was often picked at one time and piled on the ground beneath the trees, later to be graded by hand and packed in barrels.

During this period the apples underwent more or less color changes depending upon variety and length of exposure. The green ground color gradually changed to yellow or yellow-green and the amount of red coloring increased. It was also true that fruit so handled matured rather rapidly if this period of exposure was prolonged. With late keeping varieties and for a relatively short season of consumption the disadvantages of this practice were not as great as they are with early maturing varieties and for a marketing period extending over a considerable length of time.

In recent years emphasis has been placed on speeding the fruit from tree to storage as rapidly as possible. Generally this practice is right. It is well known that fruit softens rather rapidly after being detached from the tree in the temperatures usually prevailing at harvest time even for late fall and winter varieties. This softening results in shortening the storage life of the fruit.

Magness et al. (1) have shown that softening proceeds approximately twice as fast at 70° F. as at 50° F. At 50° F. the rate of softening is about twice as fast as at 40° F., and at the latter temperature softening proceeds twice as fast as at 32° F. There is considerable variation between varieties in the firmness of the flesh at the optimum time for picking and also in the rate of softening following picking.

A number of commercial varieties of apples frequently do not attain as much color as is desirable. In order to secure better color on such varieties, spot picking once a week or even oftener is resorted to with varieties like Wealthy, McIntosh, Northern Spy, and others. Most of these varieties also tend to drop badly if harvesting is deferred for the purpose of securing better color.

When sun-coloring is practiced the apples are all picked at one time. The high-colored fruit is sorted out and the undercolored exposed to the sun.

## METHODS OF SUN-COLORING

Various methods of sun-coloring have been tried. Two methods were used in the work at the Ohio Experiment Station in 1938:

1. The apples were poured a single layer deep onto clean straw mulch under the trees around the north, northeast, and northwest sides (fig. 1).

2. Apples were placed on a wire screen platform elevated about 12 inches above the ground.

If the apples are exposed to the direct rays of the sun, scald and a dull, undesirable color may result. Hoffman (2) has shown that better coloring

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1. Magness, J. R., H. C. Diehl, M. H. Haller, W. S. Graham, D. B. Canick, F. S. Howlett, R. E. Marshall, H. H. Plagge, G. J. Raleigh. Ripening, storage, and handling of apples. U. S. D. A. Dept. Bull. 1406.

2. Hoffman, M. B. 1937. Increasing the amount of red color on apples after harvest. *Proc. Am. Soc. Hort. Sci.* 35: 212-216.

effects were obtained by placing the apples in the shade of a tree than by shading them with cloth exposed to the direct rays of the sun. Satisfactory color apparently develops with low intensity of light provided a large proportion of the light is made up of short wave lengths. From a practical standpoint, of course, placing the apples in the shade of the tree is to be preferred to the use of artificial shade.



Fig. 1.—Northern Spy being sun-colored on straw mulch

### PLAN OF EXPERIMENT

The plan of the 1938 experiment was as follows:

1. The entire crop of apples of each variety used in the experiment was picked at one time.
2. Liberal tree-run samples of each variety were placed in cold storage (temperature 35 to 42° F.) as soon as picked.
3. Pressure tests were taken of each variety at the time of picking.
4. All the apples were graded for color at the time of picking. In grading, each apple was carefully inspected and rated as to color.
5. Some of the apples were placed on straw mulch as previously described, and other lots on the wire platform.
6. One week after the picking date the apples were again graded for color, and pressure tests were taken. Samples were also placed in storage at this time.

7. In some instances samples were left exposed for a few days beyond the week.

8. Daily readings of light intensity and minimum, maximum, and mean temperatures were recorded.

9. Pressure tests were taken of the stored samples at intervals (tables 2 and 3).

### LIGHT INTENSITY

Observations of the intensity of the light were made daily between 12 (noon) and 1 p. m. The maximum intensity of the light on cloudless days and in full sunlight during the period of this experiment, September 7 to October 26, ranged from 9,000 to 10,000 foot-candles. The light readings are shown in table 1. Several observations were made at each reading, and the average was recorded. The average light intensity in the open, unshaded location was less during the period the McIntosh apples were being exposed than during any other period. It will be noted, however, that the readings in the shade and over the apples on the rack and on the mulch did not vary much from period to period.

TABLE 1.—Average daily light intensity between 12 (noon) and 1 p. m. September-October, 1938

Dates	Variety under observation	Light, foot-candles at different locations				Average mean temperature
		In open	In shade on north side of tree	Under apples on wire rack	Under apples on wire over white metal	
1938:						°F.
Sept. 7-13.....	McIntosh	4,300	550	.....	.....	71
Sept. 23-29.....	Northern Spy	8,900	580	45	.....	64
Sept. 30-Oct. 7. ....	Baldwin	4,500	630	25	40	55
Oct. 7-14.....	Delicious	8,000	600	25	50	59
Oct. 15-22.....	Stayman	8,500	520	20	70	59
Oct. 20-26.....	Rome Beauty	7,000	1,250*	.....	.....	55

\*Leaves falling in abundance after Oct. 23.

### PRESSURE OF FRUIT

It is a well-established fact that apples tend to soften rather rapidly after being detached from the tree when exposed to the temperatures generally prevailing at the time of harvesting late fall and early winter varieties. The average mean temperature during the time the McIntosh apples were exposed to the coloring treatment in 1938 was 71° F. During the period the Rome Beauty fruits were exposed the average temperature was 55° F. For the other varieties the mean temperatures were: Northern Spy, 64° F., Baldwin, 55° F., Delicious, 59° F., and Stayman, 59° F.

The pressure tests as indicated by the standard pressure-testing apparatus described by Murneek (3) are shown in table 2. Unfortunately, complete pressure data were not recorded for all the varieties.

3. Murneek, A. E. 1921. A new test for maturity of the pear. Oregon Agr. Exp. Sta. Bull. 186.

TABLE 2.—Pressure tests of sun-colored fruit

Variety	Date picked 1938	Pressure of apples stored when picked		Pressure of apples sun-colored and stored 1 week after exposure		
		Day picked	Nov. 23	Day picked	Exposed 1 week	Nov. 23
		<i>Lb.</i>	<i>Lb.</i>	<i>Lb.</i>	<i>Lb.</i>	<i>Lb.</i>
McIntosh.....	Sept. 6	14.8	8.7	14.8	11.1	8.6
Northern Spy .....	Sept. 22	17.7	10.8	17.7	12.1	9.6
Baldwin .....	Sept. 29	18.9	14.6	18.9	17.3	14.8
Delicious .....	Oct. 7	16.9	.....	16.9	16.7	13.1
Stayman .....	Oct. 15	18.1	.....	18.1	14.8	.....
Rome Beauty.....	Oct. 20	17.2	.....	17.2	16.3	14.0

In table 3 the rate of softening of samples of Northern Spy which were stored immediately after picking is compared with that of other lots exposed 1 week and 12 days, respectively. From these data it will be noted that on January 4 the samples exposed 1 week before being stored were of practically the same firmness as those stored immediately after picking.

TABLE 3.—Rate of softening of Northern Spy subjected to varying periods of exposure

Samples picked September 22, 1938

Treatment of sample	Pressure readings			
	Day stored	Nov. 23	Dec. 12	Jan. 4
Stored date of picking.....	17.7	10.8	10.5	9.7
Exposed 1 week, then stored .....	12.1	9.9	10.6	9.8
Exposed 12 days, then stored .....	10.4	9.6	.....	.....

The temperatures in the blower-type cold storage used in this experiment ranged between 42 and 35° F. during the period from September 7 to January 4.

The final examination of the stored samples of varieties other than Northern Spy was made November 23. At that time the sun-colored McIntosh apples, the earliest maturing variety used in the experiments, were crisp and in fine condition. All other varieties were also in good condition. Sun-colored Northern Spy fruits were in good market condition as late as January 4. It did not appear that the keeping quality of these two varieties had been greatly impaired by their exposure for 1 week. McIntosh and Northern Spy have relatively short market seasons, and it may be that late keeping varieties would respond differently so far as storage life is concerned. Hoffman (2), working with Wealthy in New York picked September 4 when the pressure was 16.5 pounds, found on December 15 that the samples stored in a cold storage at 33° F. recorded pressures as follows: samples stored immediately after picking, 12.6 pounds; samples exposed 1 week before storing, 11.8 pounds; and those exposed 2 weeks before storing, 10.7 pounds. McIntosh picked on September 3 with a pressure of 18.2 pounds and handled in the same manner as the Wealthy, on December 15 tested, respectively, 13.0 pounds, 12.5 pounds, and 11.6 pounds. McIntosh picked September 8 testing 19.2 pounds when picked showed pressure tests on December 15 of 11.8 pounds, 11.3 pounds, and 11.0 pounds, respectively.

It seems safe to assume from the records available that the keeping quality of the fruit is not greatly impaired provided the fruit is placed in cold storage immediately after the sun-coloring process is concluded.

### COLOR CHANGES

By a superficial examination of the McIntosh apples no appreciable color change could be noted for the first 3 days after they were placed on the mulch or racks. At the end of the fourth day it was apparent that the red shades were developing, and this development continued rather rapidly for the next 3 or 4 days. The color changes occurring in 1 week on several of the varieties included in the 1938 experiments are shown in table 4.

In addition to an increase in the red overcolor, the ground color changes appreciably during the exposure. The amount of change of ground color varies a great deal with varieties. Ground color changes from the customary green or green-yellow to varying shades of yellow. This change is more noticeable in some varieties than others. Northern Spy is one of the varieties which undergo an especially marked change during a week of sun-coloring. Other varieties are similarly favorably affected in varying degrees.

For the purpose of the data presented in table 4, color standard requirements for U. S. Fancy and U. S. No. 1 grades are designated as No. 1 and No. 2, and those below U. S. No. 1, as No. 3.

The most striking change in color was effected with McIntosh, although it will be noted that good results were secured with Northern Spy and other varieties. Some samples were left exposed for a 10- or 12-day period with still further improvement in color. Exposure of McIntosh for 10 days resulted in 97.8 per cent with color above 50 per cent; 92.6 per cent were in that color grade at the end of 7 days. It should be stated, however, that the apples softened considerably during these 3 additional days.

A week will generally be sufficient to secure good color even on very green McIntosh or Northern Spy.

TABLE 4.—Effect of placing fruit under tree on improving color

Variety	Color at picking time Percentage of fruit in color grades*—			Average color	Color after 1 week of ex- posure under trees Percentage of fruit in color grades*—			Average color
	No. 1	No. 2	No. 3		No. 1	No. 2	No. 3	
McIntosh.....	31.9	39.2	28.9	Pct. 36.9	92.6	7.4	0	Pct. 66.7
Northern Spy.....	41.8	40.6	17.6	31.8	91.7	7.8	0.5	57.3
Baldwin.....	25.7	43.7	30.6	23.4	67.5	29.0	3.5	43.8
Stayman.....	77.0	19.9	3.1	46.0	91.4	7.4	1.2	65.0
Delicious.....	74.0	24.0	2.0	42.0	94.1	5.9	0	67.6

\*For convenience, the color gradations designated in table 4 are No. 1, 2, and 3. They are, in fact, U. S. Fancy, U. S. No. 1, and below U. S. No. 1, respectively. The color requirements for McIntosh are: for U. S. Fancy, 50 per cent; for U. S. No. 1, 25 to 50 per cent. For the other varieties the color grades are 33 per cent and 15 to 33 per cent. In using the terminology U. S. Fancy or U. S. No. 1, the reader will understand that the classifications in table 4 refer only to color and do not take into consideration other requirements for these grades.

The figures in table 4 show that not only was there a remarkable gain in the quantity of fruit in the No. 1 color grade due to the coloring but that the apples in the cull, or No. 3, color grade were almost entirely eliminated. The response was not so marked on Baldwin as with McIntosh or Northern Spy, and the red overcolor was not as bright. In the case of Stayman and Delicious, the samples used were of much higher color at the start of the experiment than were the McIntosh, Northern Spy, and Baldwin.

Rome Beauty apples were also used in the experimental work in 1938, but within a day or two after the exposure of this variety was started, the foliage on the trees had fallen to such an extent as to modify the shading effect previously secured. Further work will be needed to establish the value of sun-coloring with Rome Beauty.

### RACK COMPARED WITH STRAW MULCH

An effort was made to compare the amount of coloring effected by placing the apples one layer deep on wire racks about 12 inches from the ground with that obtained by laying them one layer deep on the mulch under the trees. Two racks were placed in different positions under the same tree used for securing the data on apples placed directly on the mulch.

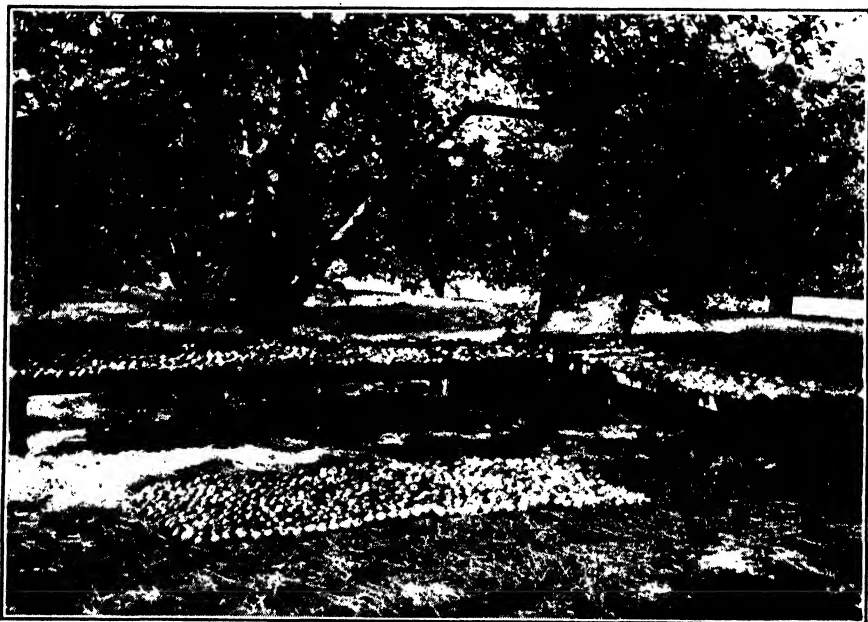


Fig. 2.—McIntosh being sun-colored on racks and straw mulch

All the apples, whether on the mulch or racks, were in the area circumscribed by an arc formed by the outward extremity of the branches on the north half of the tree. None of the apples were exposed to the direct rays of the sun for more than short periods. The effort was to place the apples out of the range of direct rays of the sun and, so far as possible, to take advantage of broken shadows.

Some data from the records of McIntosh and Northern Spy are presented in table 5 for the purpose of comparing the color effect from exposure on mulch and racks. The color improvement of both McIntosh and Northern Spy was a little greater where the apples were placed on the mulch.

TABLE 5.—Color improvement of apples on mulch compared with those on racks

Variety	Treatment	Location	Percentage of fruit in color grades—			Average color
			No. 1	No. 2	No. 3	
McIntosh	Check .....	Mulch	31.9	39.2	28.9	<i>Pct.</i> 36.9
	Exposed 1 week..	Mulch	92.6	7.4	0	66.7
	Check .....	Rack	30.2	29.7	40.1	32.8
	Exposed 1 week..	Rack	88.5	11.2	.3	65.3
Northern Spy	Check .....	Mulch	41.8	40.6	17.6	31.8
	Exposed 1 week..	Mulch	91.7	7.8	.5	57.3
	Check .....	Rack	50.2	38.9	10.9	36.4
	Exposed 1 week..	Rack	86.3	13.0	.7	55.6

Hoffman (2) reported securing improved color by placing a white oilcloth underneath the wire rack.

The mulch would appear to be much more practical than the racks, since it can be left under the tree with beneficial results to the tree. It seems likely that the coloring effects will be better where bright straw is used rather than dull. When a succession of varieties is being sun-colored, it may be feasible to haul the apples to trees where straw has been prepared for the purpose. The crop from two trees, say 25 years old and producing average-sized yields, can be spread under the north arc of a tree of the same age. Where plenty of mulch is available it would seem to be more practical to spread the apples under each tree; however, when this plan is followed some injury may result from apples falling on others under the tree during the picking operation.

### COST OF SUN-COLORING OPERATION

Sage (4) estimated the extra cost for picking up sun-colored apples at 1 cent per bushel. Hoffman (2) has stated that "An estimated cost of approximately 10 cents per bushel should cover the extra handling." Perhaps somewhere between these two estimates will be found the actual increase in cost.

In connection with this matter of cost it should be observed that the apples can be graded by hand as they are being picked up, provided laborers qualified for grading are used. This method of hand grading may not always be feasible but has much to recommend it for tender varieties like McIntosh and Northern Spy.

In connection with the sun-coloring work at the Ohio Station in 1938 some observations were made concerning the time required for picking up Northern Spy apples which had been sun-colored on straw mulch. The conditions surrounding this work would approach the methods which might be used for simi-

4. Sage, Russell D. Coloring fruit, does it pay? N. Y. State Hort. Soc. Proc. 1938. pp. 52-55.

lar operations in commercial orchards. The apples, incidentally, were the second picking from the insides of Northern Spy trees and were poorly colored when placed on the mulch.

The apples were picked up and placed in crates and graded into two salable grades; the culls were eliminated and placed in crates. Sixty bushels were picked up with the grades resulting as follows: 43 bushels in the No. 1 grade, 14 bushels in the No. 2, and 3 bushels of culls. Four and three-quarters man-hours were consumed during this operation. At 35 cents per hour for labor, the total cost for the entire operation of picking up and grading was \$1.66, or 2.8 cents per bushel. Four men were used in the work and considerable difference in the speed with which the men worked was noted. It is believed, however, that the results presented are representative of what might be expected in a well-organized commercial orchard.

Incidentally, the net profit from this particular sun-coloring operation with the No. 1 grade selling at \$1.50 per bushel, the No. 2 at 75 cents, and culls at 50 cents, after subtracting the 2.8 cents per bushel for grading, was \$14.86.

### CONCLUSIONS

Although sun-coloring is not one of the major orchard operations, under many conditions it can be used to good advantage.

When high-priced varieties like McIntosh, Spy, and perhaps Delicious do not attain good color under the ordinary cultural routine, sun-coloring will help.

Where apples are sold soon after harvest or where cold storage is available, the softening incident to the coloring operation will not be serious.

The use of mulch rather than racks seems more practical.

The quality of the fruit as represented by flavor and condition, either for dessert or culinary uses, is not impaired by a week's exposure.

If sun-coloring is practiced, the grower will be enabled to pick the entire crop at one time, and this makes for economy.

# GRAVEL CULTURE OF FLOWERING PLANTS IN THE GREENHOUSE

ARNOLD WAGNER AND ALEX LAURIE

Since 1936 the Horticulture Department of the Ohio Agricultural Experiment Station has carried on extensive experiments with the nutrient solution culture of greenhouse flowering plants in an attempt to make it useful to the commercial grower.

Gravel culture appears to have a number of advantages over the normal commercial practice of growing flowering plants in soil. No watering, no weeding, no cultivation, no fertilizing, no changing of soil are necessary, and consequently there is a great reduction in the labor required to grow a crop. By increasing or decreasing the concentration of solutions and by varying the ratio of the constituents, the type of growth can be controlled. The system is largely automatic. A large number of the soil-borne pests and diseases are absent in gravel culture. Better quality of flowers and an increase in production of roses have resulted.

## THE AUTOMATIC SUBIRRIGATION SYSTEM

A waterproof bench (made so by using pure asphalt paint), an inverted eaves trough running the entire length of the bench, a solution tank under the bench, and a time clock to operate a motor and pump automatically are essentials of the automatic subirrigation system. A centrifugal pump or sump pump may be used.

**Media.**—Practically any type of medium can be used providing its particles are of the correct size and providing it is given proper manipulation. Any medium that is too alkaline can be brought to the neutral point in about 6 weeks by addition of small amounts of sulfuric acid to the nutrient solution each time it is pumped. Media that have been used successfully are cinders, silica gravel, calcareous (lime-bearing) gravel, crushed limestone, and Haydite (a burnt clay and shale compound). The "C" grade of Haydite is recommended. Cinders should range from one-fourth to three-fourths of an inch in diameter, gravel from one-eighth to one-half inch. The medium should be 4 or 5 inches deep in the bench.

**Solutions.**—Of the various formulas tried, the WP formula, developed by floriculturists of the Ohio Agricultural Experiment Station, produced the best growth on the majority of plants.

TABLE 1.—Composition of the WP formula

Chemicals	Cost per lb.	Grams per 1,000 gal. of water	Concentration in millimoles	Millimoles of 2 WP solution
	<i>Cts.</i>			
Potassium nitrate ( $\text{KNO}_3$ ), commercial grade.....	4	2,632	6.27	12.54
Ammonium sulfate ( $(\text{NH}_4)_2\text{SO}_4$ ), commercial grade.....	2½	439	.86	1.72
Magnesium sulfate ( $\text{MgSO}_4 \cdot 7\text{H}_2\text{O}$ ), stock grade.....	2½	2,043	2.08	4.16
Monocalcium phosphate ( $\text{CaH}_4(\text{PO}_4)_2 \cdot \text{H}_2\text{O}$ ), food grade*.....	8	1,090	1.06	2.12
Calcium sulfate ( $\text{CaSO}_4 \cdot 2\text{H}_2\text{O}$ ), agricultural grade.....	1½	4,856	6.46	12.92

\*The monocalcium phosphate should be of the "food grade" because it is desirable that the fluorine content be low.

The 2 WP solution is made by adding 440 grams, or 15½ ounces, of the WP formula to 20 gallons of water. The 2 WP solution may be used for all crops.

### 2 WP solution

	Parts per Million
$\text{NO}_3$ (from potassium nitrate) .....	800
$\text{NH}_3$ (from ammonium sulfate) .....	56
Total nitrogen translated to $\text{NO}_3$ .....	1,000
(56 p. p. m. of $\text{NH}_3$ are equivalent to 200 p. p. m. of $\text{NO}_3$ , on a basis of equal amounts of nitrogen.)	
PO <sub>4</sub> .....	400
K .....	500
Ca .....	600
Mg .....	100

At the time of changing solutions, iron is added at the rate of 2.3 grams of ferrous sulfate ( $\text{FeSO}_4$ ) to 25 gallons of solution, and manganous sulfate is added at the rate of 100 cubic centimeters of a 0.5 per cent solution for 25 gallons of nutrient solution. In some cases it may be necessary to add iron once or twice a week at the rate recommended.

**Changing of solutions.**—Monthly changing of solutions is sufficient. However, weekly tests should be made of the various nutrient levels, and proper amounts added in case of low tests.

### GENERAL RECOMMENDATIONS

When the solution becomes too acid, sodium hydroxide ( $\text{NaOH}$ ) is added. In case of too alkaline a solution, sulfuric acid may be added. Nutrient solutions for roses, stocks, sweet peas, and other nearly neutral or slightly alkaline crops should be maintained at pH 6.5 to 7.0. Practically all other crops should be maintained at about pH 6.0 to 6.5. Gardenias grow best at pH 5.5 to 6.0. The success of gravel culture depends to a great extent upon the maintenance of a correct pH at all times.

Iron and phosphorus must be checked regularly.

Algal growth can be controlled successfully by pumping the solution to within 1 inch of the surface, and not flooding the surface.

Injury to roots due to sprays which may be toxic to them may be prevented by keeping the bench filled with tap water during the time of spraying. After spraying, the tap water should be emptied into an outside drain.

Sweet pea bud drop can be controlled by increasing the concentration of the solution to 4 WP (double strength).

Plants which must be grown from seed grow better if the seed is sown in sand and treated with nutrient solution. Sweet pea seed can be sown directly in the bench. For plants propagated by cuttings, the ideal method is to allow the cuttings to become thoroughly rooted in an ordinary propagating bench in sharp sand and then plant directly to the gravel bench.

A weak nutrient solution is used the first 2 weeks on all newly planted plants until they become established. A single-strength WP solution is recommended for starting all types of plants, including roses.

Cormous and bulbous crops should be planted shallow to prevent rotting.

Buds may be set on gardenias in the fall by infrequent pumpings (approximately once every 2 or 3 days) and by cooling the house temperature down to 50° F.

At the present time, dormant-started eyes of roses are preferred to grafted stock which may have to be transferred from soil to gravel culture in active growth. However, roses may be grafted in pots containing sand or fine media. The sand is watered well with 2 WP solution which will provide sufficient nutrients for 3 weeks. The pots are then placed in the grafting case for 3 weeks, during which time the union will take place. They may then be removed from the grafting case and treated with 2 WP solution until transferred to the gravel bench.

Common sense must be used in determining the number of pumpings per day for each season. In general, four or five times are necessary in summer, whereas two times are sufficient in winter. During the extremely dark, cold periods of winter, once a day is sufficient. Number of pumpings is necessarily modified by particular crops. Chrysanthemums require large amounts of water. For carnations or other crops easily infected by stem rot, less frequent pumpings, even in summer, are advisable.

Sweet peas should be planted 1½ to 2 inches deep in gravel culture to prevent drying of the young plant root system.

#### TYPICAL RESULTS OF TESTS CONDUCTED BY THE OHIO STATION

**Roses.**—The variety used was Better Times. Started eyes were planted in February 1938 and then built until July when the first roses were cut. The record includes the cut from July 1, 1938, to February 22, 1939.

TABLE 2.—Production of Better Times roses

Plot	Average number of flowers per plant
Plot 1, soil, normal commercial practice .....	14.8
Plot 2, 2 WP solution, silica gravel (pea grade) .....	23.1
Plot 3, 2 WP solution, silica gravel (pea grade) .....	23.6
Plot 4, 2 WP solution, silica gravel (pea grade) .....	21.8
Plot 5, 2 WP solution, fine silica gravel .....	23.6
Plot 6, 2 WP solution, cinders .....	27.1

It can be seen from the records that in every instance the gravel or cinder plots produced a greater number of roses than soil. These records do not mean as much as they should, since a very serious injury from mercury fumes practically defoliated the plants in November during the darkest period of the year. Undoubtedly the production would have been much higher on all plots. However, 23 to 27 flowers per plant is well above the average for Better Times grown in soil in this section of the country.

TABLE 3.—Firebird chrysanthemum in gravel culture

Plot	Treatment	Average height in bench	Number of oz. per plant	Number of plants required to make one 9-oz. bunch
1	Soil check.....	<i>In.</i> 32	3.74	2.40
2	2 WP, silica gravel, pH 4-4.5.....	31	4.36	2.06
3	2 WP, silica gravel, pH 6.5-7, spray injury to roots (later recovery).....	29	4.00	2.25
4	Silica gravel, 2D*.....	31	4.82	1.90
5	2D, limestone.....	31	4.28	2.10
6	2D, coarse local gravel (calcareous).....	32	4.52	2.00
7	2D, fine local gravel (calcareous).....	30	3.42	2.60
8	2D, cinders, insect attack.....	32	3.34	2.70
9	2W,† silica gravel (no ammonia).....	30	4.20	2.14
10	WP, silica gravel.....	32	4.20	2.14
11	2 WP, unmulched.....	31	4.00	2.25
12	2 WP, mulched with glass wool.....	33	5.92	1.52

## \*Composition of 2 D Solution

## Grams per 1,000 liters of water

Magnesium sulfate (anhydrous), $MgSO_4$	65
Treble superphosphate (0-48-0), $Ca(H_2PO_4)_2$	155
Potassium nitrate, $KNO_3$	1,100
Calcium sulfate, $CaSO_4$ , agricultural gypsum	760
Ammonium sulfate, $(NH_4)_2SO_4$	140

†The 2 W solution has the same composition as the 2 WP solution with the exception that the ammonium sulfate is replaced by an equal weight of sodium nitrate.

**Results of tests with chrysanthemums in gravel culture, summer of 1938.**—Silver Sheen and Firebird varieties were planted April 29, 1938. Those planted in gravel culture were directly from the propagating bench, from cuttings stuck April 1, 1938. Soil check plants were propagated March 7, 1938 (3 weeks before gravel culture plants) and planted out of 2½-inch pots. The solutions were changed every 2 weeks. During the active period of growth they were pumped five times daily; after the buds were well developed, three times daily. The last pinch on Firebird was made June 24. The plants were shaded from July 13 until September 10, 1938. Firebird was cut from September 18 to September 22; Silver Sheen, from September 5 to September 8.

The solutions ranked in the following order from best to poorest: 2 WP, WP, 2 D, 2 W. The poorest results of all were obtained in soil.

The media ranked in the following order from best to poorest: silica gravel, cinders, limestone (improved as particles became coated and alkalinity decreased), calcareous gravel (local, pea grade). Poorest results of all were obtained in soil. It is thought currently that limestone can be used satisfactorily once it is coated.

TABLE 4.—Silver Sheen chrysanthemum in gravel culture

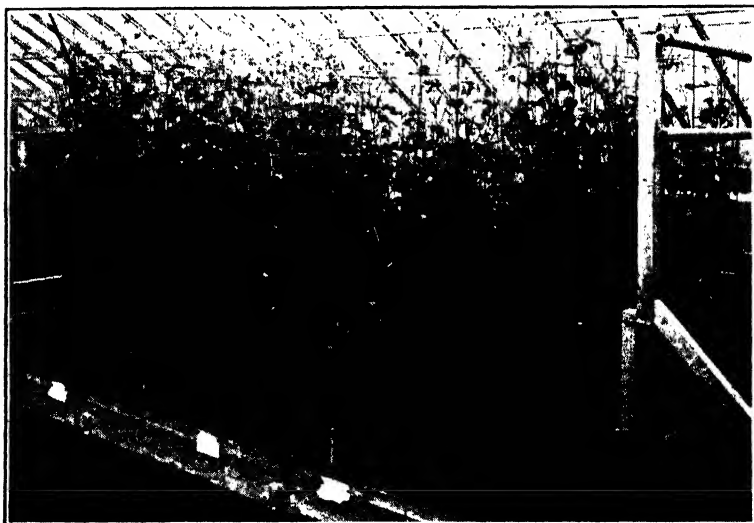
Plot	Treatment	Diameter of flower	Stem length
		<i>In.</i>	<i>In.</i>
1	Soil check.....	4½	39
2	2 WP, silica gravel, pH 4-4.5.....	5	43
3	2 WP, silica gravel, pH 6.5-7, spray injury very slight.....	5	40
4	2D, silica gravel.....	5	41
5	2D, limestone.....	5	37
6	2D, coarse local gravel (lime bearing).....	5	36
7	2D, fine local gravel (lime bearing).....	5½	35
8	2D, cinders, insect attack.....	5	39
9	2W, silica gravel (no ammonia).....	5	38
10	WP, silica gravel.....	5½	42
11	2 WP, unmulched.....	5	40
12	2 WP, mulched with glass wool.....	5	40

Fig. 1.—Chrysanthemums (variety Silver Sheen) grown in gravel culture tests, showing comparison of various types of media. Summer of 1938, 2 WP solution

The media from left to right are soil, silica gravel, cinders, limestone, pea grade calcareous gravel, and fine calcareous gravel.



The following crops have been grown successfully in gravel culture: roses, carnations, chrysanthemums, sweet peas, iris, snapdragons, daffodils, lilies, stocks, annual chrysanthemums, calendulas, larkspurs, pansies, dahlias, feverfew, Boston yellow daisies, begonias, centaureas, and marigolds.



**Fig. 2.—Sweet peas (variety Ball's Rose Improved) grown in silica gravel and limestone**

Winter of 1938-1939, 2 WP solution, later increased to 4 WP to prevent bud drop



**Fig. 3.—Wedgewood Iris grown in local calcareous gravel**

Winter of 1938-1939, 2 WP solution

# FATTENING STEER CALVES

## Varying the Amounts of Supplement and Molasses

PAUL GERLAUGH

In previous work at the Ohio Station<sup>1</sup> molasses added to a ration of shelled corn, protein supplement, silage, and hay increased feed consumption and daily gains. The addition of molasses also stimulated growth in the cattle, so that for a period of 6 months or thereabouts, the increased gains did not result in increased fatness, but with a feeding period longer than 6 months, the molasses-fed calves were as fat as or fatter than those not receiving molasses.

Work done at the Station in which a protein supplement was fed in amounts varying from 0.8 pound to 3.2 pounds indicated that the larger quantities of supplement increased feed consumption and daily gains of the calves. It was also observed that the calves receiving the larger quantities of supplement grew more during the first several months of the feeding period, so that the increased gains did not result in fatter steers until about 6 or 7 months of the feeding period had passed.

The similarity of the reaction of steer calves to the addition of molasses or to the use of larger quantities of supplement led to the test reported here. Since 1.5 pounds of a protein supplement containing about 45 per cent of protein have been more satisfactory than either larger or smaller amounts when gains, finish, and costs are concerned, this amount was used for the check lot, lot 4. Lot 5 was given 1.5 pounds of supplement and 1 pound of molasses. Lot 2 was given 2.5 pounds of supplement. Lot 3 was fed 1.5 pounds of supplement and 2.5 pounds of molasses. Lot 1 was fed 2.5 pounds of supplement and 1.5 pounds of molasses. Shelled corn was full-fed to all lots. Seven pounds of silage were fed to each calf daily throughout the test and hay was given in such amounts as the calves wanted, 1.5 pounds daily after the calves had been on test about 6 weeks.

The calves were obtained from the Panhandle section of Texas and arrived in Wooster during late October. Shipping fever developed in the calves a few days after arrival, and 6 of the 100 died; several other calves were very sick. Four of the remaining calves were sorted off, and it was thought that the remaining 90 head would probably feed satisfactorily. As the test developed, three calves did not respond satisfactorily. Two of these were in lot 2. One died December 28 and was replaced; the second was withdrawn from the lot July 5 and died a few days later. A calf in lot 5 died February 26 and another one was injured April 24 when a stomach tube used in the collection of rumen content for some other work was passed into its windpipe instead of its gullet.

In calculating the results the author has tried to be fair, but the difficulties mentioned make perfect adjustment impossible. It is felt that lot 2 has suffered somewhat. The gains by 4-week periods show lot 2 somewhat out of line during the early part of the test, owing, it is thought, in part to a few calves that were recovering slowly from the attack of shipping fever.

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<sup>1</sup>Reported in Bulletin 463 and Bimonthly Bulletins 154, 159, 166, and 173 of the Ohio Agricultural Experiment Station

TABLE 1.—Fattening steer calves, 1937-1938

Average daily gains by 4-week periods of the calves that finished the test

	Lot 1	Lot 2	Lot 3	Lot 4	Lot 5
Number of calves.....	18	17	18	18	16
Nov. 16-Dec. 14.....	2.00	1.87	2.00	2.09	2.17
Dec. 14-Jan. 11.....	1.99	1.53	1.94	1.80	1.83
Jan. 11-Feb. 8.....	2.31	2.27	2.22	1.76	1.97
Feb. 8-Mar. 8.....	2.51	2.27	2.45	2.47	2.68
Mar. 8-Apr. 5.....	2.36	2.20	2.20	1.96	2.19
Apr. 5-May 3.....	2.54	2.32	2.59	2.50	2.61
May 3-May 31.....	2.32	2.34	2.29	1.89	1.92
May 31-June 28.....	2.03	2.20	2.28	2.04	2.16
June 28-July 26.....	2.06	1.74	2.17	1.78	1.89
July 26-Aug. 23.....	1.28	1.05	1.32	1.18	1.41

Table 1 shows lots 1 and 3 as the two most rapidly gaining lots in the group. Doubtless this was to be expected. Lot 1 outgained lot 3 during the first 5 or 6 months of the test; then lot 3 forged ahead during the last 4 or 5 months. This performance is in keeping with results observed in previous tests. The larger amounts of protein have been of more value in producing increased gains on calves during the early part of the tests. Molasses has increased the performance throughout the tests, and particularly during the latter half, when the increased feed consumption due to the addition of molasses seemingly exerts itself to a greater extent.

TABLE 2.—Fattening steer calves, 1937-1938

Nov. 16, 1937, to Aug. 23, 1938 (280 days)	Lot 1	Lot 2	Lot 3	Lot 4	Lot 5
Cattle per lot.....	18	18*	18	18	18†
Feed lot cost per cwt.....	\$10.50	\$10.50	\$10.50	\$10.50	\$10.50
Weight at start of test, lb. ....	352	353	355	352	353
Weight at close of test, lb. ....	952	908	956	897	933
Average daily gain, lb.....	2.14	1.98	2.15	1.95	2.10
Average daily ration, lb.:					
Shelled corn.....	8.9	9.3	9.4	9.5	9.6
Protein supplement.....	2.5	2.5	1.5	1.5	1.5
Silage.....	7.0	7.0	7.0	7.0	7.0
Mixed hay.....	1.6	1.6	1.6	1.6	1.6
Molasses.....	1.5	.....	2.5	.....	1.0
Feed required per cwt. of gain, lb.:					
Shelled corn.....	416	468	436	485	462
Protein supplement.....	117	127	70	77	73
Silage.....	327	354	326	359	338.3
Mixed hay.....	73	80	73	81	76
Molasses.....	70	.....	116	.....	48.3
Feed cost per cwt. of gain.....	\$8.47	\$8.41	\$8.31	\$7.60	\$7.81
Gain on pigs to credit to lot, lb.....	742	634	839	699	729
Market appraisal.....	\$11.90	\$11.65	\$11.90	\$11.65	\$11.90

\*Steer replaced Dec. 28; one withdrawn July 5.

†Steer withdrawn Feb. 26; another Apr. 24.

FEED PRICES: corn, 56 cents per bu.; supplement, \$40 per ton; silage, \$4.00 per ton; hay, \$12 per ton; molasses, \$25 per ton.

Protein supplement used: tankage, 30 parts; soybean oil meal, 80 parts; cottonseed meal, 20 parts; linseed meal, 15 parts; minerals, 5 parts.

The addition of 1 pound of molasses to 1½ pounds of protein supplement, as in the case of lot 5, gave increased gains as compared with lot 4. As compared with lot 2, getting 2½ pounds of protein supplement, lot 5 gained more rapidly. How much disease may have altered this performance is not known.

The cost of gains, as shown in table 2, shows that the larger amounts of protein supplement and molasses used in lots 1, 2, and 3 would probably be greater than the increased rate of gain would justify unless the increased weight were a price factor.

The rations of lots 4 and 5 should doubtless be considered the economical ones to use. The gains in lot 5 cost a little more than the gains in lot 4, and the cattle were valued higher at the end of the test, though an additional feeding period of a month for lot 4 might have produced just as desirable a group of cattle at some slight saving in cost of gains. These points appeal differently to different feeders.

When molasses is valued at prices such as used in this test it can be used to good advantage in cattle-fattening rations. The lot 5 ration is thought to be a sane ration for use by those who want to feed both protein concentrate and molasses.

Pigs following the molasses-fed calves did considerably better than those following the calves receiving no molasses. This is in keeping with previous results.

## REDUCING THE AMOUNT OF CORN AND INCREASING THE AMOUNT OF LEGUME HAY IN RATIONS FOR FATTENING YEARLING STEERS, III<sup>1</sup>

PAUL GERLAUGH AND C. W. GAY

This test was the third of a series. The results of the first tests were reported in Bimonthly Bulletin 186 and of the second test, in Bimonthly Bulletin 192.

The two preceding tests were terminated during August, a time when the preferable finish of lots 1 and 2 might command more of a premium than in May. There has been, therefore, a change in the length of the feeding period.

As in the two preceding tests, the same amount of supplement and silage was fed to each of the lots. Corn-and-cob meal was full-fed to lot 1; lot 2 was fed three-fourths as much as lot 1 ate; and lot 3 was fed one-half as much as lot 1. Legume hay was given in such amounts as each lot wanted.

A group of pigs followed all three lots of steers and their gains were prorated to the three lots of cattle on the basis of corn fed to the respective lots.

There was less difference in the appearance of lots 1 and 2 at the close of the test than the average daily gains would indicate. In fact, they sold at the same price; lot 3 sold 85 cents per hundredweight less. It is doubtful whether one should expect the rations fed to lots 1 and 2 to produce cattle that would consistently sell at the same figure with the same length of feeding period.

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<sup>1</sup>This test was conducted in the feed lots of The Ohio State University under the supervision of C. W. Gay.

The cattle were killed by Swift and Company at their New York plant. They reported good color in all three lots. Samples of fat taken from each of the carcasses were tested colorimetrically for carotene,<sup>2</sup> and 0.4234, 0.5894, and 0.4564 milligram per kilogram were the averages for lots 1, 2, and 3, respectively. The differences in these figures are too small to indicate noticeable differences in color.

**TABLE 1.—Reducing the corn and increasing the hay for yearling steers, III  
1937-1938**

Oct. 12, 1937-May 3, 1938 (203 days)	Lot 1 Full feed of corn	Lot 2 Three-fourths full feed of corn	Lot 3 One-half full feed of corn
Number of steers per lot .....	12	12	12
Cost per cwt. in feed lot .....	\$9.00	\$9.00	\$9.00
Average weight, Oct. 12, 1937, lb. ....	660	662	648
Average weight, May 3, 1938, lb. ....	1,028	1,006	982
Average daily gain, 203 days, lb. ....	1.81	1.69	1.65
Average daily ration, lb.:			
Corn-and-cob meal .....	12.2	9.1	6.1
Supplement .....	1.5	1.5	1.5
Silage .....	13.5	14.3	14.7
Hay .....	2.5	5.2	7.2
Feed per cwt. of gain, lb.:			
Corn-and-cob meal .....	673.0	539.0	369.0
Supplement .....	83.0	88.0	91.0
Silage .....	746.0	845.0	888.0
Hay .....	138.0	309.0	437.0
Cost per cwt. of gain .....	\$9.78	\$10.23	\$9.87
Pounds of gain on hogs per lot .....	252	189	126
Acres of feed per lot:*			
Corn .....	8.478	6.358	4.239
Silage .....	1.644	1.744	1.784
Hay .....	1.517	3.184	4.391
Total acres of feed .....	11.639	11.286	10.414
Total gain per lot, lb. ....	4,410	4,127	4,017
Gain on cattle per acre, lb. ....	379	366	386
Gain on cattle and hogs per acre .....	401	382	398
Market appraisal, feed-lot weight less 3 per cent. ....	\$9.35	\$9.35	\$8.50

\*Supplement not included; yields per acre used: corn, 50 bu.; silage, 10 tons; hay, 2 tons.

Prices used: corn, 60 cents per bushel; supplement, \$36 per ton; silage, \$4.00 per ton; hay, \$15 per ton.

<sup>2</sup>By L. E. Kunkle and T. S. Sutton of The Ohio State University.

# REDUCING THE CORN AND INCREASING THE HAY CONTENT OF RATIONS FOR FATTENING YEARLING STEERS

## Summary of Three Years

PAUL GERLAUGH AND C. W. GAY

This series of tests was planned to learn more about the performance of fattening cattle when the corn content of the ration was reduced and the legume hay content was increased.<sup>1</sup> Yearling cattle were used, because it was thought that their performance on the reduced amounts of corn would be relatively more satisfactory than would that of calves. The average weights at the time the tests were started ranged from about 650 pounds to about 725 pounds. Each group of feeders graded choice.

The first of the three tests started November 26 and closed August 18; the second test started December 10 and closed August 19; the third test started October 12 and closed May 3. The lot 3 cattle in the first two tests sold noticeably lower than the lot 1 and lot 2 cattle. It was thought desirable to start the third test earlier in the fall and terminate it in the late spring, during a season when well-finished and medium well-finished cattle frequently sell closer than similar grades will during late summer.

Lot 1 was full-fed corn-and-cob meal in each of the three tests; lot 2 was fed three-fourths as much as lot 1; and lot 3 was fed one-half as much as lot 1. During a few periods of hot weather, lot 1 cattle did not clean up all their feed. The uneaten portion was weighed back. This accounts for the slight discrepancy in the daily ration figures from the above-mentioned ratio.

One and one-half pounds of protein supplement were fed daily per steer in each lot during each test. The supplement was a mixture of vegetable and animal proteins containing about 45 per cent of protein. It may be true that less protein supplement need be fed to the lots getting the larger amounts of legume hay. However, it was felt advisable to use the same amount of supplement for each lot in this series of tests and probably make use of decreased amounts of corn and supplement and increased amounts of hay in a later test.

Legume hay was used throughout the tests. For the most part it was alfalfa hay. The quality varied from poor to excellent and was poorer during the third year than either of the preceding years, because the 1936 drouth reduced the acreage of legumes available for hay production in 1937 and rainy weather prevailed during much of the haymaking season of 1937. It is safe to state that the quality of hay used in these tests was as good as if not a shade better than most Ohio cattle feeders had available. The amount of hay uneaten from one feeding to another was weighed and discarded, so that the figures used show the amount of hay eaten rather than the amounts fed. As would be expected, the hay remaining in the troughs several hours after feeding was the less desirable portion of that fed.

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<sup>1</sup>The tests were conducted in the feed lots of The Ohio State University.

During the first test the silage supply became exhausted about 1 month prior to the closing of the test.

A group of pigs had access to the three lots. The gains on the pigs were prorated to the various lots of steers according to the amount of corn fed to the steers.

The costs of gains on the cattle are shown. They are the costs prevailing during the years when the tests were run. The costs shown in the average-performance column are not averages of the costs used in the individual tests but rather what are considered somewhat normal price relationships. The acre returns are calculated yields per acre that are considered somewhat normal yields, rather than the actual yields of the feeds fed. Practically all of the corn and hay fed was purchased through dealers; many times the exact origin was not known. It is felt that anyone can use the performance data shown and apply feed, cattle, and hog values applicable to his own conditions. The same can be done with yields as they apply to acre returns.

There is no profit or loss shown per steer. The first year the steers showed a reasonable profit; the second year, a decided profit; and the third year, a slight loss. It is probably safe to say that price levels of cattle were relatively high during the period when this test was conducted. If the differences in selling value of lots 1 and 2 are averaged for the 3 years, they are found to be less than a dime per hundredweight. This would amount to about a dollar per steer on the weight of cattle used. The difference in gains of the pigs to credit to the steers in the first two lots amounted to 7 or 8 pounds per steer. These differences in selling values and pork credits were certainly not great enough to be seriously considered.

Between lots 1 and 3 there was an average difference in selling price of about 80 cents per hundredweight. This would amount to about \$9.00 per steer with the weight of cattle used. The difference in gains on the pigs to credit to each steer in lots 1 and 3 was 16 pounds in favor of the lot 1 cattle. These amounts would suggest that it is a doubtful procedure to use consistently the type of ration fed to the lot 3 cattle unless hay is very low in price.

When the cattle used in the first two tests were slaughtered, the packers reported no apparent off colors in the fat of either lot. Samples from each steer in the third test were tested colorimetrically without finding any noticeable difference in color of fat between the three lots.

Yields of 50 bushels of corn, 10 tons of silage, and 2 tons of hay per acre were used in determining the number of acres of crops consumed by the various lots. It may be worth while to note the acreages of corn and hay used by the cattle on the three levels of corn and hay feeding. The average of the 3 years of full-feeding corn shows 10.93 acres of grain and 1.99 acres of silage, a total of 12.92 acres of corn to the lot while the same lot was consuming the hay which grew on 2.32 acres. This is a ratio of 5.5 acres of corn to 1 acre of hay for the cattle fed as lot 1.

When this same basis of calculation was used for lot 2, it was found that the lot 2 cattle ate the corn, grain and silage, from 2.3 acres while eating the hay from 1 acre. Lot 3 consumed 1.2 acres of corn to each acre of hay.

A ratio of 5.5 acres of corn to 1 acre of hay, that of lot 1, would not be considered good farm practice in many, if any, locations. A ratio of 1.2 acres of corn to 1 acre of hay would be too narrow a ratio for many farmers.

Few Ohio farmers are interested in feeding all their corn and hay to fattening steers.

TABLE 1.—Reducing the corn and increasing the hay  
Summary of 3 years

	Lot 1, full feed of corn				Lot 2, three-fourths full feed				Lot 3, one-half full feed			
	1935-36	1936-37	1937-38	Average	1935-36	1936-37	1937-38	Average	1935-36	1936-37	1937-38	Average
Number per lot.....	12	12	12	.....	12	12*	12	.....	12	12	12	.....
Date test started.....	Nov. 26	Dec. 10	Oct. 12	.....	Nov. 26	Dec. 10	Oct. 12	.....	Nov. 26	Dec. 10	Oct. 12	.....
Date test closed.....	Aug. 18	Aug. 19	May 3	.....	Aug. 18	Aug. 19	May 3	.....	Aug. 18	Aug. 19	May 3	.....
Length of feeding period.....	266	252	203	240	266	252	203	240	266	252	203	240
Av. wt. of feeding period.....	699	722	660	694	699	724	662	694	699	716	648	686
Av. wt. close of test, lb.....	1,241	1,187	1,028	1,152	1,196	1,196	1,006	1,133	1,131	1,159	982	1,091
Average daily gain, lb.....	2.04	1.85	1.81	1.91	1.88	1.76	1.69	1.78	1.65	1.75	1.65	1.69
Average daily ration, lb.....	14.2	13.2	12.2	13.3	10.8	10.0	9.1	10.1	7.2	6.7	6.1	6.72
Corn-and-cob meal.....	1.5	1.4	1.5	1.5	1.5	1.4	1.5	1.5	1.5	1.4	1.5	1.5
Corn silage.....	13.0	14.6	13.5	13.7	13.1	15.0	14.3	14.1	13.1	15.0	14.7	14.2
Legume hay.....	3.2	3.8	2.5	3.2	5.8	7.4	5.2	6.2	8.7	9.9	7.2	8.7
Feed per cwt. of gain, lb.....	696	714	673	696	576	571	539	564	439	382	369	399
Corn-and-cob meal.....	74	78	83	78	80	82	88	83	91	82	91	88
Supplement.....	637	793	746	719	698	852	845	790	796	854	888	843
Silage.....	156	208	138	169	308	420	309	347	529	565	437	517
Hay.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Cost per cwt. of gain.....	\$9.34	\$18.26	\$9.78	\$10.22(a)	\$9.36	\$18.38	\$10.23	\$10.00(a)	\$9.74	\$16.82	\$9.87	\$9.36(a)
Cost per cwt. of gain.....	.....	.....	.....	\$9.80(b)	.....	.....	.....	\$9.14(b)	.....	.....	.....	\$8.07(b)
Gain on pigs per lot, lb.....	376	547	252	392	282	415	189	295	188	278	126	197
Acres of feed per lot:												
Corn.....	12.92	11.40	8.47	10.93	9.84	8.64	6.36	8.28	6.58	5.79	4.23	5.54
Silage.....	2.07	2.23	1.67	1.99	2.09	2.26	1.74	2.03	2.09	2.27	1.78	2.04
Hay.....	2.53	2.91	1.51	2.32	4.61	5.56	3.18	4.45	6.95	7.50	4.40	6.28
Total.....	17.52	16.54	11.65	15.24	16.54	16.46	11.28	14.76	15.62	15.56	10.41	13.86
Gain on cattle per acre, lb.....	371	337	379	367	362	322	366	350	336	341	386	354
Gain on cattle and hogs per acre, lb.....	392	370	401	387	379	347	382	369	349	359	398	368
Selling price of cattle.....	\$10.00	\$18.50	\$9.35	.....	\$9.75	\$18.50	\$9.35	.....	\$9.25	\$17.75	\$8.50	.....

\*Steer died August 6, gains prorated.

Feed prices used: 1935-36, corn-and-cob meal (per 70 lb.), 50 cents per bu. to July 7, \$1.00 per bu. to close of test; supplement, \$35; silage, \$4.00; hay, \$6.50 per ton. 1936-37, corn, \$1.12 per bu.; supplement, \$45; silage, \$7.50; hay, \$20. 1937-38, corn, 60 cents per bu.; supplement, \$36; silage, \$4.00; hay, \$15. Average (a) corn, 56 cents; supplement, \$30; silage, \$3.50; hay, \$5.00. (b) corn, 56 cents; supplement, \$30; silage, \$3.50; hay, \$5.00.

There is much flexibility in the ratios of corn and hay needed for fattening cattle of different ages. Fattening calves require a higher proportion of corn to hay than do yearlings. The purchase of calves and growing them for a year, on hay during winter and pasture during summer, then fattening during the second winter would change the ratio of corn and hay necessary for their growing and fattening.

Most farmers are interested in keeping more than one class of livestock on their farms, because in a combination of different classes of livestock may be found ratios of grain, hay, and pasture to fit almost any farm practices desired.

## RETURNS PER ACRE IN CATTLE FEEDING<sup>1</sup>

### Medium and Late Varieties of Corn for Silage. Silage Versus Limited Amounts of Corn-and-Cob Meal

PAUL GERLAUGH AND H. W. ROGERS

One silo was filled with corn of W17, a hybrid variety well adapted for grain production in the southwestern section of the State where the test was conducted. This silage was fed to lot 1. Another silo was filled with corn of Scioto County White, a variety adapted for grain production farther south in the State but considered a rather large-growing, good-yielding variety which has a large proportion of stover to grain. This silage was fed to lot 2. The third lot was fed corn-and-cob meal and stover from the same area of the W17 variety as was put into the silo for the lot 1 cattle. The test is in no wise to be construed as a comparison of hybrid and open-pollinated corns for silage.

All three lots were started on the same date but finished on different dates, as shown in table 1. A supplement composed of 3 parts of cottonseed meal, 3 parts of soybean oil meal, and 2 parts of tankage was used at the same rate for each of the lots.

The silage was full-fed to each lot of cattle. The difference in daily consumption of silage between the two lots was doubtless due to the moisture content of the silage. The W17 silage showed a dry matter content of 38.3 per cent; the Scioto County White showed a dry matter content of 28.9 per cent.

It was intended to feed lot 3 corn-and-cob meal at the same rate of corn area as lot 1 was given. This rate was slightly exceeded by the lot 3 cattle, as they consumed their 10.31-acre allotment in 3,184 steer-day feeds, whereas the silage-fed lot had 3,648 steer-day feeds from their 10.31-acre allotment.

Legume hay was given to all three lots in such amounts as they wanted. The lot 3 cattle were also given the stover from the 10.31 acres.

There was surprisingly little difference in the daily gains of the three lots. Most observers thought that the dry-fed cattle were more desirable in appearance when the test closed than the lot 1 cattle. These same observers also thought the lot 2 cattle a little less desirable in appearance than the lot 1 cattle.

<sup>1</sup>This test was conducted at the Madison County Experiment Farm, where H. W. Rogers is superintendent.

The pounds of gain per acre of corn and hay were favorable to the silage-fed lots of cattle. This is in keeping with previous work done at this same farm comparing acre returns of cattle full-fed silage with those of cattle full-fed corn grain.

It is noted that the lot 1 cattle consumed the corn from 10.31 acres while they were consuming the hay from 1.82 acres. This is a ratio of 5.66 acres of corn to 1 acre of hay. Such a ratio is not considered a good one by many men interested in good farming practices or soil conservation.

**TABLE 1.—Returns per acre in cattle feeding**  
Medium and late varieties for silage. Silage versus  
limited amounts of corn-and-cob meal

	Lot 1 W17 silage	Lot 2 Scioto County White silage	Lot 3 W17 corn- and-cob meal
Number of steers per lot.....	19	15	16
Cost of steers in feed lot.....	\$8.65	\$8.65	\$8.65
Average weight of steers Sept. 14.....	716	716	719
Date feed supply became exhausted.....	Mar. 25	Apr. 12	Apr. 1
Length of feeding period.....	192	210	199
Average weight of steers at close of test, lb.....	1,081	1,113	1,100
Average daily gain, lb.....	1.90	1.89	1.91
Average daily ration, lb.:			
Silage.....	43.3	52.2	.....
Corn-and-cob meal.....	.....	.....	13.6
Supplement.....	1.73	1.70	1.7
Hay.....	2.5	2.8	7.3
Feed required per cwt. of gain, lb.:			
Silage.....	2,276	2,765	.....
Corn-and-cob meal.....	.....	.....	713
Supplement.....	91	90	89
Hay.....	131	150	379
Acres of corn fed.....	10.31	8.03	10.31
Acres of hay fed.....	1.82	1.78	4.62
Acres of corn and hay.....	12.13	9.81	14.93
Yield per acre:			
Silage, tons fed.....	7.7	10.2	.....
Grain, bushels fed.....	.....	.....	60.2
Hay, tons.....	2.5	2.5	2.5
Steer days per acre of corn.....	354	392	309
Pounds of beef per acre of corn.....	673	740	591
Pounds of beef per acre of corn and hay.....	572	606	408
Supplement consumed per acre of corn and hay fed....	520	545	361
Selling price of cattle per cwt.....	\$8.65	\$8.55	\$8.75

# OLD LAYING HOUSES CAN BE MODERNIZED

D. C. KENNARD AND V. D. CHAMBERLIN

Poultrymen are more often concerned about modernizing their outmoded laying houses than with new construction. Most of the laying houses constructed within the past 10 to 20 years can be modernized and made as satisfactory as new construction. Modernization of an old laying house will generally cost much less than a new one. Moreover, the cost of remodeling can be spread over a considerable period by undertaking one step at a time.

In most instances modernization comprises five important steps, which are (in order of procedure and importance):

1. Putting on a permanent waterproof roof
2. Construction of a ceiling under the roof or a lining on the underside of the rafters and insulation of the roof
3. Removal of droppings boards and installation of droppings pits
4. Reduction of window space to about 1 square foot to each 25 to 30 square feet of floor space, elimination of windows in the rear under droppings boards, and installation of horizontal rear ventilators
5. Lining the walls with wood or galvanized sheet metal and filling the spaces between studding with planer shavings, straw, or other suitable insulation material. Needless to say, a good cement foundation and a smooth concrete floor are essential for a satisfactory laying house. If the house has an unsatisfactory foundation or floor, these improvements should be among the first undertaken.

The following steps were recently carried out at the Station's poultry plant with what was an outmoded 20 by 40-foot shed-roof laying house in a way that can be directly applied to most of the laying houses in Ohio.

**The roof.**—The old, leaky, composition roofing was covered with standing-seam galvanized sheet metal roofing. Shed roofs with comparatively little pitch require the use of standing-seam roofing. Corrugated iron roofing can be used on shed or gable roofs with one-third or one-fourth pitch. If high-quality No. 26-gauge galvanized roofing is used, the roof should require little or no attention for 10 to 12 years. After that time it will require a protective coating each 3 to 5 years to prevent deterioration. By proper and timely care such roofing can be made to serve many years.

**Windows and rear ventilators.**—After completion of the roof, the ceiling and walls were prepared for insulation. The first step was to cover the surplus windows and open space in front and eliminate the rear windows previously under the droppings boards. The next was the installation of the rear horizontal ventilators for summer ventilation. Three single sashes (six-light, 10 by 12-inch glass) were placed in front to serve each 20 by 20-foot pen (fig. 1, top). The bottoms of the sashes were placed 4 feet above the floor, and the sashes were hinged at the bottom to tilt inward for desired ventilation.

The rear summer ventilators, one for each 10 lineal feet of laying house, consist of horizontal openings 8 to 10 inches wide and 3 to 4 feet long next to the roof plate or ceiling (fig. 1, bottom). These openings were equipped with

closely fitted doors hinged at the bottom to open outward and lie flat against the rear wall when wide open during warm or summer weather. During cold or winter weather the doors are kept tightly closed.

**Insulation.**—The preparation of the ceiling for roof insulation was simplified because the underside of the rafters over the droppings boards was already ceiled with matched lumber. All that was necessary to insulate this part of the roof was to pack the spaces between the rafters with straw. From this point the ceiling was extended to the front of the house about 7 feet above the floor by means of 2 by 4-inch supports attached to each rafter where the old ceiling ended and to the front wall. As the three-V-crimp galvanized roofing was applied crosswise to the underside of the ceiling supports, 18 to 24 inches of straw were placed above, completing the roof insulation.

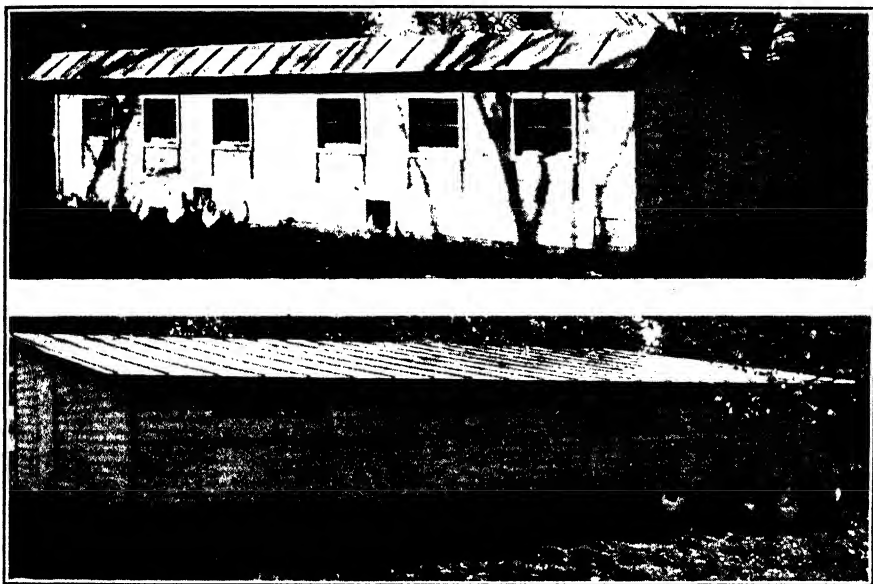


Fig. 1.—Modernized laying house

Top, front view  
Bottom, rear view

The walls were also insulated by attaching three-V-crimp galvanized metal roofing crosswise of the studding (the droppings boards were used for lining the rear wall). The spaces between the studding were then packed with shavings (straw may be used). Before the wall insulation was put in, the foundation sills were generously soaked with a half-and-half mixture of refuse auto crankcase oil and creosote oil or wood preserver. After this, about 3 inches of insulation material were put on top of the foundation sills, and this was also well soaked with the oil-creosote mixture. The oil was used to protect against deterioration of the sill, to protect against entrance of moisture from below, and to protect against growth of fungus in the insulation material from below. Moreover, this treatment protects the galvanized sheet metal (siding or lining) from corrosion due to moisture from the foundation sill or from beneath the sill.

Another important precaution too often overlooked is to use galvanized nails in attaching galvanized roofing, inside lining, and galvanized siding. Iron nails soon become unsightly and deteriorate rapidly from rust.

The use of galvanized sheet iron for the roof, ceiling, and inside lining of the walls gives rise to the question of why not go a step farther and use galvanized iron on the outside of a new laying house or where the wood siding on an old house is in poor condition. Undoubtedly there will be a more general use of galvanized metal instead of wood siding for poultry housing. A high-quality No. 26-gauge galvanized sheet metal roofing should require no cost of maintenance during the first 12 to 15 years either for the roof or the siding. After 12 or 15 years the cost of paint should be less than that of wood. It should be emphasized that the use of galvanized sheet metal roofing for the roof, ceiling, walls, and siding of poultry houses is desirable only in connection with suitable roof and wall insulation.

In general the suggestions given for the modernization of old laying houses are also applicable to the construction of new laying houses.

## COMPARATIVE EVAPORATION RATES IN NORMAL FOREST, OPEN PARK, AND CLEARED AREAS

J. D. WILSON AND R. R. PATON

During the years from 1926 to 1931, inclusive, a State-wide survey of evaporation was conducted in Ohio (1) in which Livingston white, spherical, standardized atmometers (2) were placed in cleared areas which were comparatively free of obstructions to air movement and sunlight. In the spring of 1928 a number of additional stations were established; some of these were placed in State forests, parks, or nurseries. Only white atmometers (usually three) were used at most of the stations of the State-wide survey, but black instruments (2) were included at the forest sites. At two places (Bryan Park and Shawnee State Forest) both black and white atmometers were placed in a cleared area, in an open stand of trees without undergrowth (open park), and in a normal forest with a comparatively dense stand of trees and considerable undergrowth. At the Waterloo and Wooster forests, only sites in open areas and in a normal forest were used. At Waterloo the forest consisted of a white pine planting and at Wooster it was one of mixed hardwoods. The general procedure used in collecting and recording the evaporation data at these forests was the same as that described by Wilson and Savage (1) for the larger survey. The atmometers were refilled each Monday morning from about May 1 to October 1.

Table 1 is comprised of data which represent the corrected water losses from both black and white atmometers located in sites affording three quite different degrees of exposure at Shawnee State Forest. Although these data were collected each summer from 1928 to 1931, inclusive, only those for 3 years

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1. Wilson, J. D. and J. R. Savage. 1936. An evaporation survey of Ohio. Ohio Agr. Exp. Sta. Bull. 564: 1-53.

2. Livingston, B. E. 1935. Atmometers of porous porcelain and paper, and their use in physiological ecology. Ecology 16: 438-472.

are included in the table, since some of the instruments were out of order for a short time in 1929. One of the outstanding features of these data is that evaporation at all three sites was about twice as great in 1930 as during the more normal years of 1928 and 1931. This corresponded to a State-wide average in which evaporation during the dry summer of 1930 was about 62 per cent in excess of the average for 1928 and 1931. The 3-year averages show that the sunshine (radiation) factor (B—W) accounted for 33, 24, and 16 per cent of the total loss from the black atmometer in cleared, open park, and normal forest areas, respectively. As would be expected, the relative value of the sunshine factor was much smaller during the dry year of 1930, when the loss from the white atmometer was very large (3), than it was during the more normal summers of 1928 and 1931. A comparison of the average B—W values in the three degrees of exposure shows that 43 per cent of the total radiation was intercepted by the trees in the open park area and 90 per cent of it at the normal forest site, over the period from about June 1 to September 20.

TABLE 1.—Comparative evaporation rates in three degrees of exposure at Shawnee State Forest in 1928, 1930, and 1931

	Cleared area			Open park			Normal forest		
	Black	White	B—W	Black	White	B—W	Black	White	B—W
	<i>Cc.</i>	<i>Cc.</i>	<i>Cc.</i>	<i>Cc.</i>	<i>Cc.</i>	<i>Cc.</i>	<i>Cc.</i>	<i>Cc.</i>	<i>Cc.</i>
1928 (May 22 to Sept. 17) ..	3,285	1,930	1,355	2,468	1,650	818	917	783	134
1930 (June 2 to Sept. 21) ...	5,226	4,020	1,206	4,175	3,580	595	2,054	1,915	139
1931 (June 1 to Sept. 20) ...	3,826	2,339	1,487	2,955	2,057	898	930	779	151
Averages.....	4,112	2,763	1,349	3,199	2,429	770	1,300	1,159	141

If the evaporation due to all other factors except sunshine (W values of table 1) is considered, it is found that this was reduced 12 and 58 per cent below that of the cleared area in the park and normal forest sites, respectively. Thus, in the partially sheltered areas, the relative reduction in evaporation due to other factors than sunshine was much smaller than that in evaporation due to the sunshine factor only. This reduction in evaporation from the white atmometer was, of course, largely due to the decreased temperature and rate of air movement and increased relative humidity brought about by the surrounding trees and shrubs. Dachnowski (4) found the evaporation rate from May 21 to August 14 in a maple-alder zone bordering a bog to be only 75 per cent as great as in the open near by and still less in an adjacent site which was heavily shaded. According to Transeau (5) the evaporation rate was reduced 45, 60, and 90 per cent below that in a near-by garden in the scrub trees of a forested moraine, in a heavily wooded lowland, and among a group of swamp forest shrubs, respectively. Likewise, Fuller (6) determined the evaporation rate to be about 55, 70, and 83 per cent as great in beech-maple, oak-hickory,

3. Wilson, J. D. 1939. Evaporation Studies III. Ten years of evaporation at Wooster as measured with black and white atmometers. Ohio Agr. Exp. Sta. Bimo. Bull. 24: 11-25.

4. Dachnowski, A. 1911. The vegetation of Cranberry Island (Ohio) and its relation to the substratum, temperature, and evaporation II. Bot. Gaz. 52: 126-150.

5. Transeau, E. N. 1908. The relation of plant societies to evaporation. Bot. Gaz. 55: 217-231.

6. Fuller, G. D. 1914. Evaporation and soil moisture in relation to the succession of plant associations. Bot. Gaz. 58: 193-234.

and pine areas, respectively, as in a near-by edaphic prairie. Gates (7) found it to be about 60 per cent of that in the open in a group of seedling pines in Michigan. The evaporation rate was similar in the shrubs at the edge of a bog and slightly higher in a sedge area, and in four partially shaded sites the average loss from white atmometers was 77 per cent of that from black instruments. This corresponds very closely to the relationship between 3-year-average values for the black and white atmometers in the open park area shown in table 1, in which W is 76 per cent of B.

Data published by Stickel (8) show that evaporation at the level of the duff layer in forests was approximately half that in the open for the 4 months of June to September, inclusive.

**TABLE 2.—Comparative evaporation increments due to radiation (B—W) for different 4-week periods during the summer in a cleared field, a park area, and a normal forest**

	May 2 to May 29	May 30 to June 24	June 25 to July 22	July 23 to Aug. 20	Aug. 21 to Sept. 18	Season total
Average of 1928, 1930, 1931:	<i>Pct.</i>	<i>Pct.</i>	<i>Pct.</i>	<i>Pct.</i>	<i>Pct.</i>	<i>Pct.</i>
Park .....		44.6	47.5	61.7	70.7	55.0
Field .....						
Normal forest .....		9.6	9.2	12.0	13.6	11.0
Cleared field .....						
1930 only:						
Park .....	44.9	36.3	38.9	53.4	64.2	46.5
Field .....						
Normal forest .....	21.1	10.2	9.4	13.0	14.0	13.5
Cleared field .....						

Dachnowski (4) found that the evaporation rate in the maple-alder zone at Cranberry Island varied with respect to that in the sphagnum bog when different portions of the period from May 21 to August 14 were considered. The maximum difference occurred in June and July when the leaves of the trees were most dense. The difference was less both earlier and later than this. Stickel (8) found the difference in evaporation from white atmometers located in forest and in the open to be at a maximum in August and nearly as great in July. In one instance during the month of October the loss was actually greater in the forest than it was in the open. He ascribes this to the effect of the material on the forest floor, which acted to maintain the air temperature above that in the open. A similar relationship between the evaporation from white atmometers in the cleared and normal forest sites was noticeable in data relative to the Shawnee Forest. The effect of density of leaf cover on the amount of light which penetrated to the 4-foot level (the atmometers were 4 feet above the ground) is indicated in the data of table 2. In 1930 the B—W value (radiation effect) in the open park type of woodlot was about 45 per cent of that in a cleared field during May, but as the leaves developed still further this dropped to 36 per cent in June, during which month the foliage cover

7. Gates, F. C. 1926. Evaporation in vegetation at different heights. *Am. Jour. Bot.* 13: 167-178.

8. Stickel, P. W. 1933. Relation of forests to the evaporating power of the air. *Jour. New England Water Works Assoc.* 47: 229-238.

apparently reached its maximum density. The percentage of shade then began to decrease slowly in July until in September the B—W value of the park was 64 per cent of that in the open area. The relative density of the foliage at different periods of the summer varied in much the same manner in the normal forest, with the exception that the maximum leaf cover was reached in July instead of June. When the data representing the 3-year average are considered, a gradual decrease in foliage density is noted to occur from June onward through the season in the park area and from July toward fall in the normal forest.

Evaporation data were collected at Bryan State Forest Park from 1928 to 1931, inclusive, in a manner similar to that used at Shawnee, but only those for 1929 will be discussed here because of various interruptions which occurred during each of the other years. The sunshine factor (B—W) accounted for 29.4, 13.7, and 7.6 per cent, respectively, of the total evaporation from the black atmometer from May 13 to October 13 in an open field, a park-like area, and a comparatively dense stand of hardwoods. B—W in the park area and the normal forest was 25 and 5.5 per cent, respectively, of that in the field. White atmometers in the park and normal forest lost 66 and 28 per cent as much water, respectively, as did others located in the field. These data again show that the summed effect of all factors other than sunshine on evaporation is not reduced as much as that of the latter when losses from atmometers in forested areas are compared with others in the open.

Evaporation rates from black and white atmometers located in a clearing and in the rather dense cover of an area which had been planted to white pines 10 years before at the Waterloo State Forest are shown in table 3. The B—W value was only 17 per cent as great under the pine branches as in the cleared area. The white atmometers lost 54 per cent as much water in the forest as in the open. These values are more or less intermediate between those for the park and normal forest areas at the Shawnee and Bryan Park forests. Here

TABLE 3.—Evaporation from black and white atmometers in an open area and a pine planting over a period of 3 years at Waterloo State Forest

	Open area			Pine forest		
	Black	White	B-W	Black	White	B-W
	Cc.	Cc.	Cc.	Cc.	Cc.	Cc.
1928 (May 29-Sept. 17).....	2,858	1,893	965	772	642	130
1929 (May 27-Sept. 15).....	2,962	1,876	1,086	1,232	1,059	173
1930 (June 2-Sept. 24).....	4,892	3,985	907	2,714	2,516	198
Averages.....	3,571	2,585	986	1,573	1,406	167
Averages of 4-week periods	May 30 to June 26	June 27 to July 24	July 25 to Aug. 21	Aug. 22 to Sept. 18	May 30 to Sept. 18	
W losses in open.....	542	643	750	649	2,584	
W losses in forest.....	333	369	358	346	1,406	
B-W in open.....	294	303	230	153	980	
B-W in forest.....	42	43	43	39	167	
W (forest) W (open).....	61.4	57.4	47.7	53.3	54.3	
B-W (forest) B-W (open).....	14.3	14.2	18.7	25.5	17.0	

again there was an increase in the relative values of B—W in the pine forest as compared with those of the open area from July to September. This was rather surprising, since pine trees do not usually lose as large a percentage of their leaves with the approach of fall as do most hardwoods. Evaporation from both the black and white instruments may also have been influenced to some extent by the temperature factor, as suggested by Stickel (8). B—W made up 27 and 7 per cent of the total loss from the black instruments in the open and in the forested area, respectively.

Black and white instruments were placed in a small forested area at Wooster which was covered with second-growth hardwoods of various species. The data were then compared with those collected in an open area near the campus of the Experiment Station. The evaporation rates at these two sites are given in table 4 for the years 1930 and 1931. The sunshine factor (B—W) in the forested area varied with reference to that in the open much as it did at the other stations reported, being at a minimum in June and July and increasing in August and September. Only 9.5 per cent of the sunshine available penetrated to the 4-foot level of the evaporimeters during the period from June 1 to September 20. The B—W value accounted for 28.6 and 5.5 per cent of the total evaporation in the open and forested areas, respectively. The white atmometer lost about 60 per cent as much water in the forest as in the open area, which compared with values of 42, 28, and 54 per cent in forested areas at the Shawnee, Bryan Park, and Waterloo State forests, respectively. These differences were due, of course, to variations in the density of the vegetation at the different sites. The high value at Wooster can be partly accounted for by the fact that the smallness of the forested area made it resemble the park areas of the Shawnee and Bryan Park State forests more closely than did their own normal forests.

**TABLE 4.—Evaporation from black and white atmometers in a cultivated area and a small forest of mixed hardwoods at the Wooster Experiment Station**

	Weather station			Normal forest		
	Black	White	B—W	Black	White	B—W
1930 (June 2–Sept. 21) .....	6,174	4,777	1,397	2,078	2,924	154
1931 (June 1–Sept. 20) .....	4,821	3,273	1,548	2,020	1,894	126
Averages .....	5,498	4,025	1,473	2,549	2,409	140
A averages of 4-week periods	June 1 to June 28	June 29 to July 26	July 27 to Aug. 23	Aug. 24 to Sept. 20	June 1 to Sept. 20	
W losses in open .....	952	1,142	1,119	813	4,026	
W losses in forest .....	607	656	660	487	2,410	
B—W in open .....	399	446	348	281	1,474	
W in forest .....	33	37	35	35	140	
W (forest) .....	Pct. 62.7	Pct. 57.5	Pct. 59.0	Pct. 59.9	Pct. 59.8	
W (open) .....						
B—W (forest) .....	8.3	8.3	10.1	12.4	9.5	
B—W (open) .....						

## SUMMARY

In the spring of 1928 black and white atmometers were placed in sites of different exposure at some of the State forests in Ohio. These sites were represented by a field or cleared area of uninterrupted air movement and sunshine, an open park in which there were scattered large trees but no undergrowth, and a normal forest which usually consisted of a stand of second-growth trees of medium density in which there was the average amount of undergrowth. These stations were continued over a period of 4 years, but all the data collected are not reported here because of interruptions of various types in their continuity. The use of both black and white atmometers made it possible to determine variations in the influence of the light factor on evaporation independently of those of other factors. In an average of the data from four stations, the radiant energy (as represented by B—W values) which penetrated to the 4-foot level in a normal forest and in a park-like area was only 10.5 and 41 per cent, respectively, of that in the open, over a 16-week period from about June 1 to September 20; B—W values made up 29.6, 18.8, and 9.1 per cent of the total loss from the black atmometer in the cleared, open park, and normal forest areas, respectively. White atmometers, which may be said to measure the evaporation due to all factors other than sunshine, lost 77 and 46 per cent as much water in the open park and normal forest areas, respectively, as in the cleared, or open, areas. The first value given represents the average of two stations and the latter an average of four.

# INDEX NUMBERS OF PRODUCTION, PRICES, AND INCOME

J. I. FALCONER

In February 1939, Ohio farm prices were 80 per cent of parity. During January and February, Ohio farm products prices were 21 per cent below those prevailing during the same months of 1938, whereas the prices paid by farmers for commodities purchased were down 6 per cent.

## Trend of Ohio prices and wages, 1910-1914=100

	Wholesale prices, all commodities U. S.	Weekly earnings N. Y. State factory workers	Prices paid by farmers	Farm products prices U. S.	Ohio farm wages	Ohio farm real estate	Ohio farm products prices	Ohio cash income from sales
1913.....	102	.....	101	101	104	100	105	101
1914.....	99	100	100	101	102	102	105	109
1915.....	102	101	105	98	103	107	106	112
1916.....	125	114	124	118	113	113	121	123
1917.....	172	129	149	175	140	119	182	201
1918.....	192	160	176	202	175	131	203	243
1919.....	202	185	202	213	204	135	218	270
1920.....	225	222	201	211	236	159	212	230
1921.....	142	203	152	125	164	134	132	134
1922.....	141	197	149	132	145	124	127	133
1923.....	147	214	152	142	166	122	134	147
1924.....	143	218	152	143	165	118	133	150
1925.....	151	223	157	156	165	110	159	180
1926.....	146	229	155	145	170	105	155	183
1927.....	139	231	153	139	173	99	147	171
1928.....	141	232	155	149	169	96	154	163
1929.....	139	236	153	146	169	94	151	172
1930.....	126	226	145	126	154	90	128	142
1931.....	107	207	124	87	120	82	89	105
1932.....	95	178	107	65	92	70	63	77
1933.....	96	171	109	70	74	59	69	87
1934.....	110	182	123	90	77	63	85	102
1935.....	117	191	125	108	87	66	110	132
1936.....	118	199	124	114	100	71	118	152
1937.....	126	215	130	121	118	75	128	162
1938.....	115	207	122	95	117	74	103	138
1937								
January...	125	209	130	131	104	.....	128	147
February...	126	211	132	127	.....	.....	127	141
March.....	128	218	132	128	.....	75	129	167
April.....	128	219	134	130	118	.....	134	182
May.....	127	219	134	128	.....	.....	135	162
June.....	127	220	134	124	.....	.....	134	162
July.....	128	218	133	125	123	.....	138	174
August.....	128	220	132	123	.....	.....	135	167
September...	128	215	130	118	.....	.....	129	164
October.....	125	214	128	112	127	.....	123	165
November...	122	205	127	107	.....	.....	116	161
December...	119	207	126	104	.....	.....	114	147
1938								
January...	118	201	126	102	115	.....	109	139
February...	116	204	126	97	.....	.....	105	125
March.....	116	205	125	95	.....	74	106	135
April.....	115	204	125	94	116	.....	104	132
May.....	114	201	125	92	.....	.....	104	139
June.....	114	202	124	92	.....	.....	106	136
July.....	115	205	123	95	119	.....	106	157
August.....	114	208	122	92	.....	.....	100	139
September...	114	214	121	95	.....	.....	102	139
October.....	113	212	121	95	119	.....	96	136
November...	113	207	121	94	.....	.....	98	142
December...	112	212	120	96	.....	.....	98	141
1939								
January...	112	211	120	94	115	.....	94	118
February...	112	.....	120	92	.....	.....	94	117





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## Ohio Agricultural Experiment Station

WOOSTER, OHIO, U. S. A.



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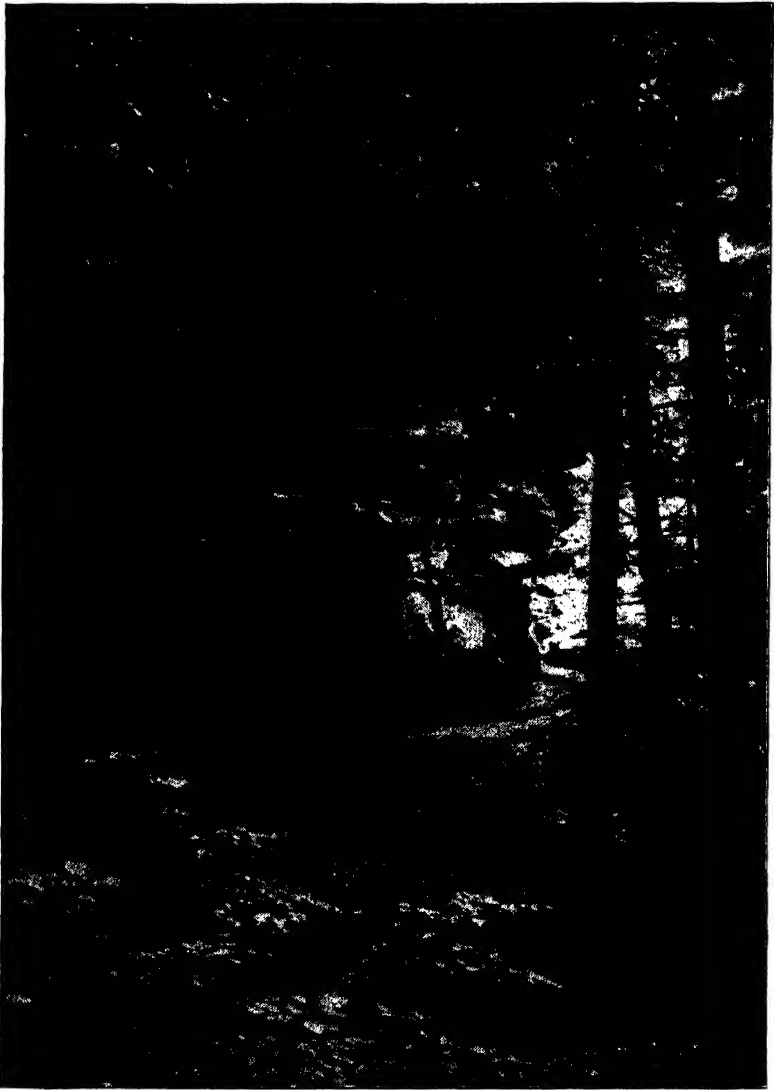
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Director



**The Rock House Forest Park from the east approach**

# ORIGIN OF MECHANICAL INJURIES TO APPLES

C. W. ELLENWOOD AND J. H. GOURLEY

Mechanical injuries of apples incident to production and marketing are of vital concern to grower, merchant, and consumer. Bruising is one of the principal causes of placing apples in the cull grade.

When apples reach the consumer in a bruised condition the blame for the injuries is very apt to be charged to the grower although it is obvious that every movement of the fruit from tree to kitchen offers possibilities for bruising.

The Experiment Station in 1936 started some studies to determine, if possible, the amount of bruising caused by the various picking and grading operations. This article is a partial report of the results secured from observations made at the Station during the harvesting of apples in 1936, 1937, and 1938.

## PLAN OF PROJECT

### 1936

Three varieties of apples were used, McIntosh, Grimes, and Stayman. About 15 bushels of each variety were picked to be used for check samples and grading operations. Extreme care was used by the workman in picking these samples.

Three men were used as pickers. Each man was identified by number, and the apples he picked were stored under the designated number.

Three different picking containers were used, the conventional padded picking bucket, the canvas bag, and a one-half bushel basket lined with heavy canvas.

Two types of field containers, an ordinary field crate and the standard bushel basket, were used. A half-ton pickup truck and a horse-drawn wagon mounted on flexible springs were used to convey the apples from the orchard to the packing shed.

The apples were sized on an electric-motor-driven, commercial, rubber sizing belt type of grading machine.

Samples of 2 bushels or more were taken after each picking or grading operation and placed in cold storage.

About 3 months after harvest the apples were all individually examined, and each bruise discernible was recorded.

### 1937

The 1937 observations were in the main a continuation of the plan inaugurated in 1936, with the following exceptions: Only two varieties were used, McIntosh and Stayman. The basket was not used as a picking container. A new set of men (Nos. 4, 5, 6) were used as pickers. Only the crate was used as an orchard container.

1938

Owing to a light crop, only one variety, Baldwin, was used in 1938. The plan of the work was almost the same as in 1937. The men designated as Nos. 1, 2, and 4 were used as pickers.

### COMMENTS ON METHODS OF PROCEDURE

A total of 248 bushels of apples was included in the experiments in 1936, 124 bushels in 1937, and 62 in 1938. Thus a total of 434 bushels of apples was used in the work during the 3 years. Each apple was examined individually after having been in storage for approximately 3 months. By this time the apples had matured sufficiently to enable detection of even slight indentations of the skin.

**Grade standards.**—The ordinary standards used to define grade requirements do not give a mathematical rating as to bruising tolerance permitted. The reference to bruising in the U. S. D. A. official standards for apple (1) provides that apples to meet the requirements for U. S. Fancy or U. S. No. 1 grades shall be free from unhealed broken skins and bruises ("except those incident to proper handling and packing"). The foregoing definition has no reference to hail marks. In the work reported here, only bruises resulting from picking and handling are being considered.

In order that some exact measurement might be used to determine the amount of bruising, it was decided to count each bruise on every apple and to classify the fruit into three groups: (a) fruit having fewer than five bruises per apple; (b) fruit having more than five bruises per apple but no evidence of broken skin; and (c) fruit on which the skin had been broken during the process of harvesting, grading, or storing.

The writers realize that the arbitrary grade standards set up for the purpose of this study are not altogether satisfactory and caution the reader not to confuse them with commercial grades. The first classification, that of "less than five bruises per apple", is a much more rigid standard than would be found in the average U. S. Fancy or U. S. No. 1 fruit when it reaches the consumer.

Some observations were made during the progress of the work to estimate the proportion of the area of skin showing bruises according to the arbitrary grade standards used. These observations were not extensive enough to make definite conclusions but did indicate that on the average "five bruises" included about 5 per cent of the total area of the apple surface.

No attempt was made to associate decay with bruises in this study, but aside from the specimens showing broken skins, no decay was noted at the time of examination. The depth of the bruises ranged from only a slight trace of discoloration immediately beneath the skin to one-eighth of an inch or more. It is generally accepted by grower, dealer, and consumer that bruising constitutes one of the hazards in handling fruit and that to some extent it is unavoidable. It is not the purpose of this discussion to suggest any definite tolerance for bruising. The authors have only attempted to measure the more important sources of bruising resulting from the ordinary picking and harvesting operation. Any interpretation of the data here presented must take into consideration the rather severe scale of measurements used.

---

1. Official standard for apples. U. S. D. A. Service and Regulatory Announcements. August, 1931.

## BRUISING ON TREES

In the data presented in table 1 an effort has been made to determine the amount of bruising caused by wind, falling, and any other sources of bruising before the apples are picked. The apples from which these data were secured were picked by a careful workman and carefully laid into a crate. Even though gloves are used in the picking operation, it is not possible to avoid some bruising in even the most careful picking. The results shown in table 1 do, however, represent the nearest approach to check samples it was possible to secure. It is very evident that bruising caused by wind was a negligible matter in the 3 years. It can be safely asserted that unless a wind velocity of hurricane proportions occurs shortly before harvest time, apples are not seriously bruised on the trees.

TABLE 1.—Bruising on trees  
Condition of apples picked as check samples in 1936, 1937, and 1938

Variety	Year	Number of bruises per 100 apples	Bruised fruit		
			Less than five bruises per apple	Five or more bruises per apple	Skin broken
			<i>Pct.</i>	<i>Pct.</i>	<i>Pct.</i>
McIntosh .....	1936	158	98.3	0.2	1.5
Grimes .....	1936	57	99.6	.2	.2
Stayman .....	1936	86	99.8	0	.2
McIntosh .....	1937	145	93.3	1.5	5.2
Stayman .....	1937	59	98.4	0	1.6
Baldwin .....	1938	78	100.0	0	0
Average .....		97	98.2	.3	1.5

No effort was made to determine the amount of injury caused by limb-rub, which Gaston (2) found to be an important cause of placing otherwise good fruit into the B and cull grades.

## RECORD OF PICKERS

There is no doubt that the human factor is one of the most important considerations in establishing the cause and origin of bruises in all the picking and grading operations. It is perhaps fair to state that the prevailing opinion among fruitgrowers is that rough handling by pickers is the most common source of bruises. The data presented in table 2 show that there was considerable difference between pickers in the number of bruises recorded. In securing these data each picker picked a given amount of fruit into the various picking containers. Every effort was made to conceal from the picker that samples of his work were to be preserved for record. There is some suggestion from these data to associate speed in picking with number of bruises. In harvesting the fruit the pickers were supplied with 20-foot ladders, and an effort was made to

2. Gaston, H. P. 1927. Why a cull apple is a cull. Mich. Agr. Exp. Sta. Spec. Bull. 160.

preserve samples picked from all sections of the tree. Perhaps the most significant result shown in table 2 is that picking was a much less serious source of bruising than some of the grading operations.

TABLE 2.—Record of six pickers  
Bruises per 100 apples

Picker No.	Variety	Year	Bushels per hour	Number of bruises per 100 apples
1.....	McIntosh	1936	6.5	283
1.....	Grimes	1936	6.5	250
1.....	Stayman	1936	8.0	344
1.....	Baldwin	1938		178
Average.....				264
2.....	McIntosh	1936	4.5	208
2.....	Grimes	1936	4.6	181
2.....	Stayman	1936	6.7	201
2.....	Baldwin	1938		114
Average.....				176
3.....	McIntosh	1936	5.0	250
3.....	Grimes	1936	5.2	244
3.....	Stayman	1936	8.0	268
Average.....				254
4.....	McIntosh	1937	5.4	286
4.....	Stayman	1937	6.8	281
4.....	Baldwin	1938		147
Average.....				238
5.....	McIntosh	1937	5.6	280
5.....	Stayman	1937	5.9	319
Average.....				300
6.....	McIntosh	1937	6.4	373
6.....	Stayman	1937	6.1	360
Average.....				367

### PICKING CONTAINERS

An effort was made to compare three different types of picking containers as to their influence on bruising (table 3). After the first year the use of the basket was discontinued. The comparison between bucket and bag indicates that there was relatively little difference in these two containers in the matter of preventing bruises.

**TABLE 3.—Relations of picking containers to bruises**  
 Bucket and bag compared. Samples from three pickers each year

Container	Year	Varieties included	Bruises per 100 apples	Bruised fruit		
				Less than five bruises per apple	Five or more bruises per apple	Skin broken
Bucket	1936	{ McIntosh } { Grimes } { Stayman }	233	<i>Pct.</i> 93.5	<i>Pct.</i> 6.1	<i>Pct.</i> 0.4
Bag			236	95.3	4.4	.3
Basket			277	93.1	6.4	.5
Average.....			249	93.9	5.7	.4
Bucket	1937	{ McIntosh } { Stayman }	276	79.8	17.6	2.6
Bag			324	74.4	21.7	3.9
Basket			300	77.1	19.7	3.2
Average.....						
Bucket	1938	{ Baldwin }	156	98.1	1.9	0
Bag			143	99.2	.4	.4
Basket			150	98.7	1.1	.2
Average.....						
Bucket	3-year average		222	90.5	8.5	1.0
Bag	3-year average		234	89.6	8.8	1.6
Basket	1-year average		277	93.1	6.4	.5

### EMPTYING PICKING CONTAINERS

The data presented in table 4 compare apples emptied by the picker in the usual way with fruit picked by the same men but transferred by carefully lifting each apple by hand from the picking container into the field crate.

**TABLE 4.—Bruising caused by emptying picking containers into field crate**  
 Three varieties, 1936, two varieties, 1937

Method of emptying	Year	Bruises per 100 apples	Bruised fruit		
			Less than five bruises per apple	Five or more bruises per apple	Skin broken
Ordinary.....	1936	282	<i>Pct.</i> 92.2	<i>Pct.</i> 7.5	<i>Pct.</i> 0.3
Ordinary.....	1937	330	74.4	22.9	2.7
Ordinary.....	2-year average	306	83.3	15.2	1.5
By hand.....	1936	253	95.1	4.7	.2
By hand.....	1937	260	84.9	13.5	1.6
By hand.....	2-year average	257	90.0	9.1	.9

That the act of emptying the picking container into the orchard crate is one of the principal sources of bruising in the orchard is shown in table 4. A little more bruising resulted from emptying the bucket into the crate than from emptying the bag.

### CRATE AND BASKET COMPARED AS ORCHARD CONTAINERS

A comparison between the ordinary orchard crate and bushel basket as orchard containers is shown in table 5. There was no significant difference in the amount of bruising in these two types of orchard containers.

**TABLE 5.—Bruising of apples in crate and basket orchard containers**

Three varieties: McIntosh, Grimes, Stayman, 1936

Container	Number of bruises per 100 apples	Bruised fruit		
		Less than five bruises per apple	Five or more bruises per apple	Skin broken
Crate.....	263	<i>Pct.</i> 93.4	<i>Pct.</i> 6.1	<i>Pct.</i> 0.5
Basket .....	233	94.3	5.4	.3

### VARIETAL DIFFERENCE

It is to be expected that the amount of handling bruises will vary a good deal with varieties. Only four varieties were used here. Summer varieties like Transparent and Melba undoubtedly are much more susceptible to bruising than any of the four varieties used in this work. Moreover, it is to be expected that the maturity of the apples at picking time would need to be considered in appraising this factor. The varieties used in this work (table 6) were all picked at as near the optimum time as it was possible to judge by the usual indexes of maturity, such as color, ease of separation, and pressure of fruit.

**TABLE 6.—Varietal difference in amount of bruising**

Composite samples from all pickers and picking containers

Variety	Year	Bruises per 100 apples	Bruised fruit		
			Less than five bruises per apple	Five or more bruises per apple	Skin broken
McIntosh.....	1936	255	<i>Pct.</i> 97.5	<i>Pct.</i> 2.2	<i>Pct.</i> 0.3
McIntosh.....	1937	313	75.1	20.7	4.2
McIntosh.....	2-year average	284	86.3	11.5	2.2
Stayman.....	1936	268	87.8	11.5	.7
Stayman.....	1937	320	75.9	21.8	2.3
Stayman.....	2-year average	294	81.8	16.7	1.5
Grimes .....	1936	223	96.6	3.1	.3
Baldwin.....	1938	150	98.7	1.1	.2

### BRUISING DURING TRANSPORTATION FROM ORCHARD TO PACKING ROOM

An effort was made to determine the amount of bruising occurring during the movement of the apples from the orchard to the packing shed from one-fourth to one-third of a mile away over a dirt roadway of average smoothness. A pickup truck and a horse-drawn wagon with a platform mounted on springs were used as means of transportation. Slightly fewer bruises resulted from the wagon method (table 7). In both cases the drivers of the vehicles were instructed to drive carefully.

**TABLE 7.—Bruising resulting during transportation from orchard  
to packing room**

Truck and wagon, 1936

Method of transportation	Bruised fruit		
	Less than five bruises per apple	Five or more bruises per apple	Skin broken
	<i>Pct.</i>	<i>Pct.</i>	<i>Pct.</i>
Check .....	99.2	0.2	0.6
Wagon .....	95.6	3.9	.5
Truck .....	92.7	7.0	.3
Average of samples transported .....	94.1	5.5	.4

It is obvious that rough spots along the road, careless operation of the truck, or even reckless driving with a horse-drawn wagon can be the source of serious bruising.

### GRADING OPERATIONS

An effort was made to ascertain the amount of bruising occurring during the process of sizing. The apples were run over a motor-driven commercial sizing machine with the perforated rubber belt type of sizing device. For the purpose of this phase of the study, the fruit was handled in the normal manner. Three varieties were used in 1936, two in 1937, and one in 1938. In table 8 the varieties used in 1936 are grouped together. This is also done for 1937. The data presented here show the bruising resulting from dumping the apples onto the table leading onto the sizer and the bruising found after the apples had passed over the sizer, through the bins, and finally into the crates ready for storage.

It is obvious from the data shown in table 8 that the grading operations are a much more serious source of bruising than picking and transportation to storage. There was not a great deal of difference in the amount of bruising during the grading process between varieties used in 1936. Stayman had slightly more bruises than either McIntosh or Grimes, but they were less noticeable on this variety. In 1937 the amount of bruising was about the same on each of the varieties used. Baldwin apparently is much more resistant to serious bruising than the other three varieties.

**TABLE 8.—Bruising resulting from grading apples**  
**Mechanical grader**

Treatment	Year	Variety	Bruised fruit		
			Less than five bruises per apple	Five or more bruises per apple	Skin broken
Check	1936	McIntosh Grimes Stayman	<i>Pct.</i> 94.1	<i>Pct.</i> 5.5	<i>Pct.</i> 0.4
After being dumped on sizer table			75.7	19.4	4.9
Over sizer			40.8	54.4	4.8
Check	1937	McIntosh Stayman	95.9	.7	3.4
After being dumped on sizer table			41.6	54.6	3.8
Over sizer			33.0	64.4	2.6
Check	1938	Baldwin	100.0	0	0
After being dumped on sizer table			98.2	.9	.9
Over sizer			92.3	6.4	1.3

### SUMMARY AND CONCLUSIONS

The foregoing notes and tables show that every movement of the apples from tree to storage is a possible source of bruising.

Bruising on the trees prior to picking is of minor consequence.

There was an appreciable difference between pickers. More bruises were found on the apples picked by the fastest workmen.

The picking operations were the source of fewer bruises than the grading operations.

There was no material difference in the amount of bruises found on the apples picked into the different picking containers.

Not much difference in bruising was noted between the apples conveyed from orchard to packing room in crate and basket.

Emptying the picking container into the orchard crate was an important source of bruising.

The most serious source of bruising was the grading operation.

Sponge rubber or some other equally efficient padding material should be used wherever possible about the bins and tables of the sizing machine.

The human factor, particularly during the grading operations, should be carefully scrutinized.

# THE DISTRIBUTION OF BLACK RASPBERRY ROOTS UNDER MULCH AND CULTIVATION TREATMENTS

LEON HAVIS

The studies here reported are concerned with investigations made of the roots of Logan black raspberries grown under straw mulch and cultivation systems at the Ohio Experiment Station at Wooster. A brief report of certain phases of these studies has already been made (1), but as this article is not available to most growers, much of the material published there, as well as some additional observations, is given here. The distribution of apple tree roots under mulch and cultivation in the same soil type has been described by Ellenwood and Gourley (2). The distribution of raspberry roots is somewhat different, however, in several respects, as will be brought out in this report. These studies were made in order to understand and correlate the differences in growth and yield obtained under mulch and cultivation in this raspberry planting. Studies on the effects of straw mulch on the growth and production of this crop at Wooster have already been reported (3). They showed that both the number and diameter of the canes, as well as the total yield of fruits, were somewhat greater under the mulch treatment. The differences were not as striking, however, as those recently obtained with red raspberries at Beltsville, Maryland, at higher temperatures and on lighter and more sandy soils (4). There is no doubt that the mulching of raspberries is a valuable practice in some locations and that it will probably be more extensively used where such factors as erosion, moisture supply, and berry protection are especially important. The studies here reported show the relative number and distribution of the raspberry roots of various sizes under the two soil treatments and their relationship to present cultural practices.

## METHODS USED

The studies reported here were made during August and September of 1938 in a very uniform block of raspberries set out in the spring of 1930. The plants were set 2 feet apart in rows 9 feet apart. The mulch treatment described was begun in the fall of 1932, and enough wheat straw has been applied since then to keep the soil well covered and to eliminate weed growth almost completely in both the rows and middles. An application of 3 to 4 tons of straw annually was usually sufficient. The cultivation treatment has been continuous since the plants were set. The relatively large number of roots near the surface under this treatment indicates that many of them were not destroyed by cultivation.

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1. Havis, Leon. 1939. Influence of certain cultural systems upon root distribution of black raspberries. *Proc. Amer. Soc. Hort. Sci.* 36: 478-480.

2. Ellenwood, C. W., and J. H. Gourley. 1937. Cultural systems for the apple in Ohio. *Ohio Agr. Exp. Sta. Bull.* 580.

3. Havis, Leon. 1937. Results of mulching black raspberries. *Ohio Agr. Exp. Sta. Bimo. Bull.* 22: 18-20.

4. Darrow, George M., and J. R. Magness. 1939. Investigations on mulching red raspberries. *Proc. Amer. Soc. Hort. Sci.* 36: 481-484.

In order to locate the roots in some detail, trenches were dug in two different directions. The position which proved most satisfactory was at right angles to the row. One plant was first removed and then the trench was dug 2 feet wide, or about 1 foot from a plant on each side (fig. 1). This trench was 10 feet in length or 5 feet from the row in both directions and deep enough to be below all roots. The other type of trench used was located parallel to the rows and was 7 feet in length and about 2 feet from the plants. The side of the trench nearer the row was used in mapping the roots. In general, the results were similar to those secured with the other type.



Fig. 1.—One type of trench used to locate and map raspberry roots

This trench is at right angles to the row. The soil profile is divided into 1-foot squares by use of string as shown.

Colored pencils were used to designate the various root diameters, which were separated approximately into those 0-½ millimeter, ½-1 millimeter, 1-2 millimeters, 2-3 millimeters, 3-4 millimeters, and over 4 millimeters. Those indicated as over 4 millimeters averaged about 5 millimeters in diameter. The roots were then mapped to scale and photographed. With the aid of Dr. G. W. Conrey and Mrs. Grant Mickelson of the Agronomy Department of the Ohio Station, the principal changes in the soil profile were noted. Seven trenches were prepared and four of them were mapped on both sides. Thus a total of 11 charts was made. There was some difference due to variations in the soil profile, but in general, the same variations between treatments obtained.

## RESULTS

The soil was classified as a shallow phase of the Wooster silt loam. It is well drained and a good orchard soil. The 8 to 10 inches of surface are composed of grayish- to yellowish-brown silt loam. Below this surface there is a horizon which varies in thickness from 6 to 10 inches composed of a slightly heavier yellowish-brown silt loam that is lower in organic matter than the horizon above. Immediately below this horizon, and extending to a depth of 24 to 30 inches is a horizon of rather compact yellowish-brown silt loam in which many pebbles of sandstone were found. At approximately 24 to 30 inches the glacial drift, composed largely of sandstone, was encountered. Many weathered sandstone fragments which had evidently been disturbed by glacial action were found here. Where this layer was not extremely compact, the raspberry roots grew for from several inches to as far as 2 feet into it, depending on its compactness. No sharp change in root distribution due to change in soil profile was noted until this glacial drift was encountered. There was a fairly gradual decline in number of roots from a few inches below the surface to the drift of sandstone.

It has often been suggested that probably the raspberry roots are nearer the surface under mulch than under cultivation. There was no significant difference, however, in the depth of rooting under the two treatments given. Roots were usually found at a depth of between 4 and 5 feet under both treatments. The lateral distribution of the roots was also similar under the two treatments. The deepest roots were usually immediately below the plant. There was some tendency for fibrous roots to develop just under the mulch and in the mat of partly decomposed straw, but less than for apple tree roots in the same soil type.

Maps were prepared of the five profiles under mulch and the six under cultivation. The numbers and the percentages of roots of various sizes at different levels were calculated for each profile. The average results obtained when all profiles under each treatment were considered proved reliable enough for general conclusions on depth of rooting, lateral distribution, and total number of roots found. Individual comparisons, however, between two profiles showing relatively similar positions of the various horizons, proved more significant in the calculation of the numbers and percentages of roots of different sizes at each 1-foot level. Hence the data presented in the tables represent comparisons of specific profiles rather than averages. Two detailed comparisons are given, one between profiles III (cultivation) and V (mulch) and the other

between profiles II (cultivation) and IV (mulch). The first two profiles are also shown in figures 2 and 3. These two comparisons were chosen for presentation because they represented two somewhat different soil profiles although the same soil type.

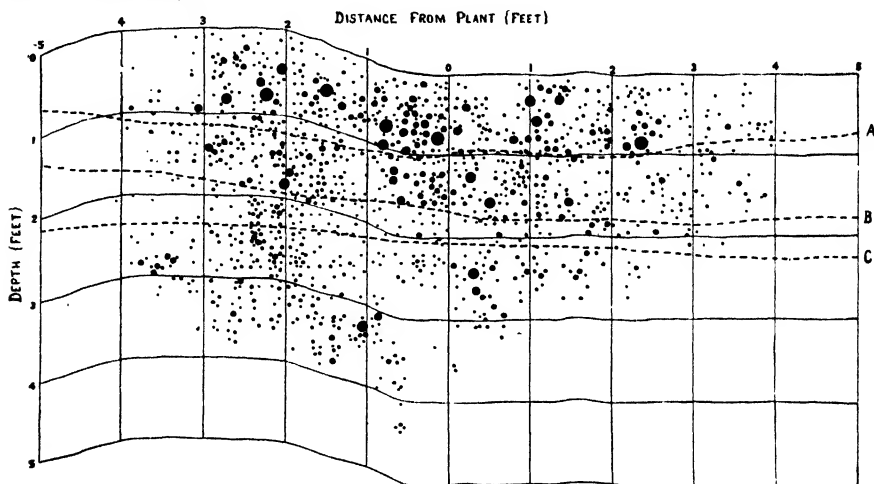


Fig. 2.—Profile III showing raspberry root distribution under cultivation

Compare with figure 3. The broken lines A, B, and C in both figures are used to designate the general soil differences. Above A, grayish-brown undifferentiated silt loam; between A and B, yellowish-brown to brown silt loam with indications of fragmentary structure; between B and C, yellowish-brown silt loam with numerous pebbles; below C, glacial drift with many weathered sandstone fragments

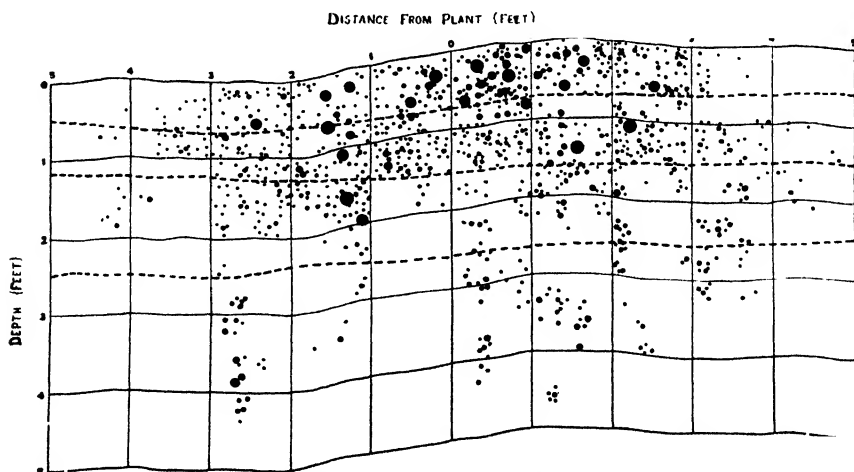


Fig. 3.—Profile V, typical example of raspberry root distribution under straw mulch

Compare with figure 2. The broken lines shown represent the same soil profile changes as shown there.

## COMPARISON OF PROFILES III AND V

Profile III (fig. 2) represents a good example of the root distribution found in cultivated Wooster silt loam soil. The location of the various principal soil horizons is shown in the figure and explained in the legend. Profile V (under mulch) is similarly illustrated and explained in figure 3. The roots extend to a depth of about 4½ feet in both. The roots extend to only about 3 feet on each side of the row under cultivation (fig. 2) and to a slightly greater distance under mulch (fig. 3). The roots under 1 millimeter in diameter were more numerous under cultivation to a depth of 4 feet. In this comparison, however, there were a few more roots between 4 and 5 feet under the mulch. There was also a tendency for the larger-sized roots to be more numerous under the mulch (table 1). As shown in table 1, however, the total number of roots was greater under cultivation.

TABLE 1.—Numbers of roots of various sizes at different depths  
under mulch and cultivation  
Profiles III and V

Depth	Root diameters						Total	
	0-1 mm.		1-3 mm.		3+* mm.		Mulch	Cultivation
	Mulch	Cultivation	Mulch	Cultivation	Mulch	Cultivation		
<i>Ft.</i>								
0-1.....	370	382	31	63	13	5	414	450
1-2.....	338	373	15	46	5	3	358	422
2-3.....	107	201	4	21	0	1	111	223
3-4.....	52	84	10	7	0	1	62	92
4-5.....	12	5	2	0	0	0	14	5
Total.....	879	1,045	62	137	18	10	959	1,192

\*Average approximately 4 mm.

The relative depth of roots of different sizes may be illustrated more clearly when the percentage in each size range is calculated for each specific level (table 2). For example, 89 per cent of the total number of roots to a depth of 1 foot under mulch were under 1 millimeter in diameter. Eighty-five per cent of those at that level under cultivation were under 1 millimeter in diameter. In this particular comparison there was a tendency for the roots to be larger under cultivation to a depth of 3 feet. This result is not significant, however, when all trenches are compared.

TABLE 2.—Percentage of roots at each level of the three sizes  
Profiles III and V

Depth	Root diameters						Total	
	0-1 mm.		1-3 mm.		3+* mm.		Mulch	Cultivation
	Mulch	Cultivation	Mulch	Cultivation	Mulch	Cultivation		
<i>Ft.</i>	<i>Pct.</i>	<i>Pct.</i>	<i>Pct.</i>	<i>Pct.</i>	<i>Pct.</i>	<i>Pct.</i>	<i>Pct.</i>	<i>Pct.</i>
0-1.....	89	85	7	14	3	1	99	100
1-2.....	94	88	4	11	1	1	99	100
2-3.....	96	90	4	9	0	0	100	99
3-4.....	84	91	16	8	0	1	100	100
4-5.....	86	100	14	0	0	0	100	100

\*Average approximately 4 mm.

The percentage of roots of each size at different depths was calculated for profiles III and V (table 3). For example, as shown in the table, 42 per cent of the smaller roots (under 1 mm.) under mulch and 37 per cent of those under cultivation were in the first foot. It may be noted that the larger roots were more numerous under the mulch.

**TABLE 3.—Percentage of roots of each size at different depths**  
Profiles III and V

Depth	Root diameters					
	0-1 mm.		1-3 mm.		3+ *mm.	
	Mulch	Cultiva- tion	Mulch	Cultiva- tion	Mulch	Cultiva- tion
<i>Ft.</i>	<i>Pct.</i>	<i>Pct.</i>	<i>Pct.</i>	<i>Pct.</i>	<i>Pct.</i>	<i>Pct.</i>
0-1.....	42	37	50	46	72	50
1-2.....	39	36	24	34	28	30
2-3.....	12	19	6	15	0	10
3-4.....	6	8	16	5	0	10
4-5.....	1	0	3	0	0	0
Total percentage.....	100	100	99	100	100	100

\*Average approximately 4 mm.

#### COMPARISON OF PROFILES II AND IV

A comparison of profiles II (cultivation) and IV (mulch) serves very well to illustrate two comparable soil profiles in which the soil differs in certain respects from that just described. Profiles II and IV are also in Wooster silt loam. The soil was higher in organic matter in the first 18 inches and there were more pebbles at the lower depths than where profiles III and V were located.

The roots in this comparison are here also more numerous under cultivation in all sizes except the few over 3 millimeters in diameter. The most significant differences, however, are in those under 1 millimeter in diameter in the first 3 feet. This difference may be accounted for by the greater branching of the roots under cultivation, especially where the soil is relatively porous. These results are in sharp contrast with those obtained with apple roots under similar soil conditions, as little or no difference was found between the number of apple roots under cultivation and mulch except for the mass of roots just under the mulch (2).

The percentage of roots of any given size to a depth of about 3 feet is not significantly different between treatments (table 5). There is a tendency for larger roots to be more numerous and to extend to a greater depth under mulch.

Table 6 illustrates clearly the similarity of the percentage of roots of any size at various levels and the gradient in the number of roots from the surface downward.

TABLE 4.—Numbers of roots of various sizes at different depths under mulch and cultivation

Profiles II and IV

Depth	Root diameters						Total	
	0-1 mm.		1-3 mm.		3+* mm.		Mulch	Cultivation
	Mulch	Cultivation	Mulch	Cultivation	Mulch	Cultivation		
<i>Ft.</i>								
0-1.....	374	476	34	46	12	6	420	528
1-2.....	323	440	20	31	4	2	347	473
2-3.....	152	175	8	12	1	1	161	188
3-4.....	24	27	2	2	0	1	26	30
4-5.....	8	5	1	0	0	0	9	5
Total.....	881	1,123	65	91	17	10	963	1,224

\*Average approximately 4 mm.

TABLE 5.—Percentage of roots of the three sizes at each level

Profiles II and IV

Depth	Root diameters						Total	
	0-1 mm.		1-3 mm.		3+* mm.		Mulch	Cultivation
	Mulch	Cultivation	Mulch	Cultivation	Mulch	Cultivation		
<i>Ft.</i>	<i>Pct.</i>	<i>Pct.</i>	<i>Pct.</i>	<i>Pct.</i>	<i>Pct.</i>	<i>Pct.</i>	<i>Pct.</i>	<i>Pct.</i>
0-1.....	89	90	8	9	3	1	100	100
1-2.....	93	93	6	7	1	0	100	100
2-3.....	94	93	5	6	1	1	100	100
3-4.....	92	90	7	7	0	3	99	100
4-5.....	89	100	11	0	0	0	100	100

\*Average approximately 4 mm.

TABLE 6.—Percentage of roots of each size at different depths

Profiles II and IV

Depth	Root diameters					
	0-1 mm.		1-3 mm.		3+* mm.	
	Mulch	Cultivation	Mulch	Cultivation	Mulch	Cultivation
<i>Ft.</i>	<i>Pct.</i>	<i>Pct.</i>	<i>Pct.</i>	<i>Pct.</i>	<i>Pct.</i>	<i>Pct.</i>
0-1.....	42	42	52	51	70	60
1-2.....	37	39	31	34	24	20
2-3.....	17	16	12	13	6	10
3-4.....	3	2	3	2	0	10
4-5.....	1	0	2	0	0	0
Total percentage.....	100	99	100	100	100	100

\*Average approximately 4 mm.

## SUMMARY AND CONCLUSIONS

Logan raspberry roots were found near the surface of the soil under both mulch and cultivation treatments, but even in the first foot there were more roots under the cultivated treatment. This was true of roots of all sizes except those over 3 millimeters in diameter, and these represented only about 3 per cent of the roots under mulch and about 1 per cent of those under cultivation in the first foot of soil (tables 2 and 5). About 90 per cent of the roots in the first foot under both treatments were less than 1 millimeter in diameter (tables 2 and 5). Of the total number of roots of that size, approximately 40 per cent were in the first foot, 38 per cent in the second, 17 per cent in the third, 4 per cent in the fourth, and 1 per cent in the fifth foot of soil under both treatments (tables 3 and 6). There was no great mass of fibrous roots just under the mulch as is found with apple roots in similar soil. The distribution of the roots over 3 millimeters in diameter was somewhat different. Under the mulch there were about 70 per cent in the first foot, 25 per cent in the second, 5 per cent in the third, and none in the fourth and fifth (tables 3 and 6). Under the cultivated treatment there were approximately 60 per cent in the first, 20 per cent in the second, 10 per cent in the third, 10 per cent in the fourth, and none in the fifth foot. The total number of roots over 3 millimeters in diameter was, however, greater in the mulch than in the cultivated treatment.

The total number of roots under the cultivation treatment was larger than the total under the mulch. In general, this was true of roots of all sizes except those over 3 millimeters in diameter. Actual counts of roots on two comparable profiles resulted in a total of 963 roots under mulch and 1,224 under cultivation. Counts of roots in all other trenches substantiated this relationship. Roots of the larger sizes were more numerous under the mulch and they were less branched and straighter. There was a decreasing gradient in number of roots of all sizes from the surface foot of soil downward, as well as from the base of the plant outward, although the latter trend was not so marked (tables 1 and 4).

The roots were most numerous at 18 to 24 inches from the plant. The roots of the 9-year-old plants failed to extend well into the centers between the rows 9 feet apart. There was a gradual reduction in number of roots of all sizes as the distance from the plant was increased and a sharp reduction at about 3 feet from it. This result suggests that the rows could well be closer together than 9 feet if economy of space is an important factor. On soils similar to Wooster silt loam probably a distance of 6 feet would be more economical of space. In the placement of fertilizers under similar conditions, it would seem that along the sides of the rows and to a distance of 2 to 3 feet outward would be most economical.

# THE EFFECT OF SYNTHETIC GROWTH SUBSTANCES ON THE ROOTING AND SUBSEQUENT GROWTH OF ORNAMENTAL PLANTS

L. C. CHADWICK AND D. C. KIPLINGER

Recently it has been found that indolebutyric and naphthaleneacetic acids are effective in causing quicker rooting on cuttings of ornamental plants (1). As a result of this discovery the floriculture division of the Ohio Agricultural Experiment Station has conducted a series of investigations to determine the value of these substances to the field of commercial floriculture.

## MATERIALS AND METHODS

Crystals of indolebutyric and naphthaleneacetic acids were obtained,<sup>1</sup> and the desired solutions to be used in treating cuttings were prepared by dilutions from a stock solution stored at room temperature in the dark. The stock solution was prepared by dissolving 1 gram of the crystals in 125 cubic centimeters of 95 per cent ethyl alcohol and adding enough distilled water to make 250 cubic centimeters. The strength of the stock solution was 4 milligrams per cubic centimeter. The dilutions from this stock solution were used only once, though preliminary experiments had shown that dilute solutions could be used for 72 hours without appreciable loss of effectiveness.

Recently several growth substances containing various materials have appeared on the market. One of these dusts which contains naphthaleneacetic acid has been tested in order to compare solution and dust treatment of cuttings. Dusting cuttings saves time and is a convenience for the commercial grower because it requires no measurements or dilutions. Cuttings were treated by dipping the basal inch in the dust and stirring in the powder. After treatment the cutting was removed, tapped lightly to remove excess dust, and stuck into the rooting medium. Recent tests have shown that wetting the basal inch of the cutting before dusting gives better results, as more dust adheres to the cutting.

The cuttings of greenhouse plants were made in the usual commercial manner as described by Laurie and Chadwick (2 and 3). Leaf areas were kept at a maximum because better rooting responses were obtained that way. Following their preparation, the cuttings were bunched, held with a rubber band,

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<sup>1</sup>From the Merck Chemical Co., Eastman Kodak Co., and Pennsylvania Chemical Co.

1. Zimmerman, P. W., and Frank Wilcoxon. 1935. Several chemical growth substances which cause initiation of roots and other responses in plants. *Contrib. Boyce Thompson Inst.* 7:209-229.

2. Laurie, Alex, and L. C. Chadwick. 1934. Commercial flower forcing. pp. 178-179. P. Blakiston's Son and Co., Inc., Philadelphia, Pa.

3. Laurie, Alex, and L. C. Chadwick. 1931. The modern nursery. pp. 171-175. The Macmillan Co., New York.

and placed in glass tumblers containing 100 cubic centimeters of the desired solution. About 1 to 1½ inches of the basal end of the cutting were immersed. The tumblers and cuttings were placed in a north lean-to propagation house where relative humidity was maintained between 60 and 80 per cent. When the cuttings were removed from the solutions (after a 24-hour soaking period), they were stuck in the commercial manner (2) into a greenhouse bench containing sand or sand and peat (two to one by volume) which had been sterilized 2 hours by the tile method. The lean-to was heavily shaded with whitewash in summer, and the air temperature varied between 10 and 15 degrees lower than the thermostatically controlled bottom heat of 74° F. during the cool months. The usual care was given the cuttings during the rooting period.

## RESULTS

**Hardwood cuttings.**—Comparisons were made between cuttings of *Ligustrum vulgare* taken daily from November 25 to December 24, some treated with indolebutyric acid, 5 milligrams per 100 cubic centimeters, and others untreated (check), and cuttings taken on November 25 and stored with their basal ends in moist peat at 80 to 84° F. From this latter group, cuttings were removed daily from November 26 to December 25 and treated with 5 milligrams of indolebutyric acid per 100 cubic centimeters for 24 hours. All cuttings were rooted in sand in a closed case at 80 to 84° F.

The untreated cuttings were found to root best. By December 8 all cuttings had callused, but the differences in the percentage rooting before and after this date were negligible.

Hardwood cuttings of the Barbara Ecke Poinsettia taken in January and treated with 1, 3, and 5 milligrams per 100 cubic centimeters of naphthalene-acetic and indolebutyric acids for 24 hours gave 70 per cent rooting for an average of all treatments. Untreated cuttings showed 10 per cent over a 6-week period.

**Softwood cuttings.**—The following list of woody plants responded to treatment with both dusts and solutions. Softwood cuttings were taken from the latter part of May through August on many of those listed.

*Abelia grandiflora*  
*Ampelopsis tricuspidata*  
*Buddleia hybrida*  
*Callicarpa giraldiana*  
*Caragana arborescens*  
*Caragana microphylla*  
*Celastrus orbiculatus*  
*Celastrus scandens*  
*Cephalanthus occidentalis*  
*Cornus alba*  
*Cornus florida rubra*  
*Cornus mas*  
*Cornus paniculata*  
*Deutzia carnea*  
*Deutzia gracilis*  
*Deutzia lemoinei*  
*Deutzia scabra*  
*Diervilla sessilifolia*  
*Elaeagnus longipes*  
*Euonymus alatus*  
*Euonymus bungeanus*  
*Euonymus europaeus*

*Philadelphus grandiflorus*  
*Philadelphus lemoinei*  
*Philadelphus microphyllus*  
*Philadelphus virginialis*  
*Physocarpus amurensis*  
*Physocarpus opulifolius*  
*Prunus cerasifera pissardi*  
*Prunus cerasifera shirifugen*  
*Rhamnus chadwicki*  
*Rhamnus frangula*  
*Rhodotypos kerrioides*  
*Rhus canadensis*  
*Ribes alpinum*  
*Ribes odoratum*  
*Rosa Max Graf*  
*Spiraea bumalda* Anthony Waterer  
*Spiraea latifolia*  
*Spiraea nipponica rotundifolia*  
*Spiraea prunifolia*  
*Spiraea reevesiana*  
*Spiraea thunbergi*  
*Symphoricarpos chenaulti*

<i>Exochorda giraldi</i>	<i>Symphoricarpos racemosus laevigatus</i>
<i>Exochorda grandiflora</i>	<i>Symphoricarpos vulgaris</i>
<i>Forsythia intermedia</i>	<i>Syringa vulgaris</i>
<i>Forsythia suspensa</i>	<i>Viburnum americanum</i>
<i>Forsythia viridissima</i>	<i>Viburnum burkwoodi</i>
<i>Ginkgo biloba</i>	<i>Viburnum carlesi</i>
<i>Hydrangea quercifolia</i>	<i>Viburnum dentatum</i>
<i>Hypericum prolificum</i>	<i>Viburnum dilatatum</i>
<i>Ligustrum amurense</i>	<i>Viburnum lantana</i>
<i>Ligustrum ibota regelianum</i>	<i>Viburnum lentago</i>
<i>Ligustrum ovalifolium</i>	<i>Viburnum opulus</i>
<i>Lonicera bella</i>	<i>Viburnum pubescens affine</i>
<i>Lonicera fragrantissima</i>	<i>Viburnum rhytidophyllum</i>
<i>Lonicera korolkowi</i>	<i>Viburnum sieboldi</i>
<i>Lonicera morrowi</i>	<i>Viburnum utile</i>
<i>Lonicera tatarica</i>	<i>Viburnum venosum</i>
<i>Lonicera xylosteum</i>	<i>Viburnum venosum canbyi</i>
<i>Periploca sepium</i>	<i>Weigela hybrida Eva Rathke</i>
<i>Philadelphus coronarius</i>	<i>Weigela rosea</i>

The most typical responses noted on treated cuttings of woody ornamentals were the production of better quality root systems and a decrease in the time required for rooting. In most cases more roots were produced on the treated areas of the stem when proper concentrations of solutions were used. The use of high concentrations (1 mg. per 100 cc. for 24 hours) early in the season resulted in injury to the treated portion. This high concentration is best used when the material becomes more mature. In no case did the use of dust result in injury. Many authors report that the rooting percentage is increased when cuttings are treated with synthetic growth substances. This is partially true, as, based on the period the cuttings are in the bench, the rooting percentage is increased on treated cuttings over untreated. Since untreated cuttings will eventually root, the time required for rooting is decreased as a result of treatment.

Softwood cuttings of a variety of greenhouse material were also tested, and a list of the species used includes:

<i>Ageratum houstonianum</i>	<i>Euphorbia fulgens</i>
<i>Antirrhinum majus</i>	<i>Euphorbia pulcherrima</i> <sup>2</sup>
<i>Bouvardia humboldti</i>	<i>Felicia amelloides</i>
<i>Buddleia asiatica</i>	<i>Gardenia veitchi</i>
<i>Buddleia hartwegi</i>	<i>Hedera helix</i>
<i>Centaurea cineraria</i>	<i>Hydrangea hortensis</i> <sup>2</sup>
<i>Centaurea gymnocarpa</i>	<i>Jasminum astrum parqui</i>
<i>Chorizema ilicifolium</i>	<i>Labonia floribunda</i>
<i>Chrysanthemum frutescens</i>	<i>Lantana camara</i> <sup>2</sup>
<i>Chrysanthemum hortorum</i> <sup>2</sup>	<i>Lantana sellowiana</i>
<i>Chrysanthemum parthenium</i>	<i>Nerium oleander</i>
<i>Chrysanthemum segetum</i>	<i>Pelargonium hortorum</i> <sup>2</sup>
<i>Cissus rhombifolia</i>	<i>Piqueria trinervia</i>
<i>Cytisus canariensis</i>	<i>Pothos aureus</i>
<i>Dahlia variabilis</i>	<i>Rochea species</i>
<i>Dianthus caryophyllus</i> <sup>2</sup>	<i>Rosa hybrida</i> <sup>2</sup>
<i>Euonymus japonicus variegatus</i>	

Results similar to those secured with softwood cuttings of woody ornamentals were noted. A better quality root system and a decrease in the time required for rooting were obtained.

<sup>2</sup>Many commercial varieties of these plants were tested to determine their response.

In table 1 are shown results obtained by treatments of cuttings of a large variety of greenhouse plants. The quality of the root system produced by treated cuttings was superior over the period of time the cuttings were allowed to root. Table 2 shows a similar relationship in regard to softwood cuttings of a large variety of woody ornamental plants.

**TABLE 1.—Comparison of the average for softwood cuttings of greenhouse plants to show the quality of the root systems produced by a commercial dust and optimum concentrations of indolebutyric acid solutions**

Treatment	Quality of root system Per cent producing—			Per cent rooted
	Good	Poor	None	
Check .....	18	68	14	86
Dust .....	40	43	17	83
Optimum indolebutyric acid solution .....	94	5	1	99

**TABLE 2.—Comparison of the average for softwood cuttings of some woody ornamental plants to show the quality of the root systems produced by a commercial dust and various concentrations of indolebutyric acid solutions**

Treatment	Quality of root system Per cent producing—			Per cent rooted
	Good	Poor	None	
Check .....	10	25	65	35
Dust .....	39	19	42	58
Indolebutyric acid:				
0.5 mg. per 100 cc.....	56	18	26	74
1 mg. per 100 cc.....	45	29	26	74
2 mg. per 100 cc.....	46	25	29	71

Chadwick (4) has reported that some plants exhibit specificity in regard to the location of external root emergence. Softwood cuttings of some of the plants mentioned (4) were treated with 1 milligram of indolebutyric acid per 100 cubic centimeters for 24 hours for comparison with untreated cuttings. Basal cuts were made one-fourth to one-half inch below and above the nodes and through the nodes. *Ginkgo biloba* and *Caragana arborescens* rooted only at the basal cut regardless of its relation to the node. More roots were produced as a result of treatment. *Forsythia suspensa* and *Physocarpus amurens* rooted at the node in all cases. *Clethra alnifolia* produced more roots in vertical lines below each bud on treated cuttings, but the relative position of the roots remained unchanged. Cuttings of *Pyracantha coccinea pauciflora* produced roots only in the axil of the bud or thorn even when treated with concentrations of indolebutyric acid as high as 15 milligrams per 100 cubic centimeters for 24 hours. The place of external emergence was not changed on any of the material studied.

Softwood cuttings of plants normally difficult to propagate by cuttings gave variable responses. Treatment of *Cornus florida rubra* using indolebutyric acid at 1 milligram per 100 cubic centimeters for 24 hours gave 90 per cent rooting in 6 to 7 weeks. Treated and untreated cuttings of *Hydrangea petiolaris* failed to root after 4 months in the bench.

4. Chadwick, L. C. 1933. Studies in plant propagation. The influence of chemicals, of the medium, and the position of basal cut on the rooting of evergreen and deciduous cuttings. Cornell Univ. Agr. Exp. Sta. Bull. 571: 1-53.

**Narrowleaf evergreens.**—Most narrowleaf evergreens produce roots with no relation to nodes or internodes. The effect of indolebutyric acid on plants of this type is marked. In table 3 are shown results obtained with cuttings of *Juniperus chinensis pfitzeriana*, *Thuja plicata atrovirens*, and *Taxus cuspidata* taken in February. The higher concentrations of indolebutyric acid resulted in the production of fewer roots at the basal cut and more roots farther up the stem from the base on Pfitzer juniper. *Taxus* and *arborvitae* exhibited similar responses but less marked. This response has also been noted on many soft-wood cuttings of shrubs and greenhouse plants.

**TABLE 3.**—Percentage of root distribution on some narrowleaf evergreen cuttings from the base up in centimeter increments

Plant	Treatment in mg. per 100 cc.	Centimeters from the base									
		1	2	3	4	5	6	7	8	9	10
<i>Juniperus chinensis pfitzeriana</i>	Check	84	11	.....	5	.....	.....	.....	.....	.....	.....
	IB 1*	79	16	4	.....	1	.....	.....	.....	.....	.....
	IB 3	52	32	9	5	2	.....	.....	.....	.....	.....
	IB 5	60	16	10	9	4	1	.....	.....	.....	.....
	IB 10	40	18	14	13	9	4	2	.....	.....	.....
	IB 15	29	27	18	14	7	4	1	.....	.....	.....
<i>Thuja plicata atrovirens</i>	Check	51	18	8	12	8	1	2	.....	.....	.....
	IB 1	89	4	5	1	1	.....	.....	.....	.....	.....
	IB 3	75	18	5	2	.....	.....	.....	.....	.....	.....
	IB 5	43	23	12	12	7	3	.....	.....	.....	.....
	IB 10	28	24	14	15	10	5	2	1	.....	1
	IB 15	20	18	21	18	15	7	1	.....	.....	.....
<i>Taxus cuspidata</i>	Check	100	.....	.....	.....	.....	.....	.....	.....	.....	.....
	IB 5	98	2	.....	.....	.....	.....	.....	.....	.....	.....
	IB 10	79	2	18	1	.....	.....	.....	.....	.....	.....
	IB 15	95	5	.....	.....	.....	.....	.....	.....	.....	.....

\*IB—indolebutyric acid.

The production of roots far from the basal cut is undesirable, as many roots will be broken off or destroyed in the potting process. Minimum concentrations of growth substances should be used. Dusted cuttings do not exhibit the reaction described.

Root measurements taken on *Juniperus chinensis pfitzeriana* are shown in table 4. There was no apparent consistent relation between the concentration of growth substance used and the number and length of roots produced. Table 4 also shows that over the period the cuttings were in the bench, treated cuttings rooted in greater numbers than untreated. As the cuttings passed through their rest period, lower concentrations were required, and they resulted in the production of longer roots. Recent tests with *Taxus cuspidata* have shown that 95 per cent rooting may be obtained in 2 months by wetting the basal end of the cutting, dusting with growth substance, and sticking the cutting into the bench. It is probable that this method should be followed for treatments of all types of cuttings.

Treatments of *Juniperus virginiana keteleeri* and *Juniperus virginiana cannarti* with various concentrations of indolebutyric acid resulted in no rooting over a 4-month period for tests conducted in 1937-1938 and again in 1938-1939.

TABLE 4.—The effect of exposure, media, and treatment with indolebutyric acid on the rooting of *Juniperus chinensis pfitzeriana* cuttings

Date	Treatment	Average number of roots per cutting	Average total length of roots per cutting in centimeters	Per cent rooted
Nov. 18 .....	Check	1.22	18.64	10
Nov. 18 .....	IB 5	4.18	12.68	42
Nov. 18 .....	IB 10	3.92	12.95	51
Nov. 18 .....	IB 15	2.75	9.33	27
Dec. 19 .....	Check	2.20	15.27	6
Dec. 19 .....	IB 5	4.93	17.11	19
Dec. 19 .....	IB 10	6.81	14.91	20
Dec. 19 .....	IB 15	5.70	17.33	13
Jan. 21 .....	Check	1.44	16.15	11
Jan. 21 .....	IB 5	12.35	25.18	58
Jan. 21 .....	IB 10	19.67	18.32	45
Jan. 21 .....	IB 15	14.75	22.59	70
Feb. 24 .....	Check	1.00	140.00	5
Feb. 24 .....	IB 1	7.00	47.97	65
Feb. 24 .....	IB 3	8.93	25.67	75
Feb. 24 .....	IB 5	6.50	62.91	70

**Broadleaf evergreens.**—Cuttings of *Pyraecantha coccinea pauciflora* taken in November, December, and January and treated with 5, 10, and 15 milligrams per 100 cubic centimeters of indolebutyric acid and 200, 700, and 1,100 parts per million of nitrogen (using urea alone and in all possible combinations) showed that 5 and 10 milligrams of indolebutyric acid alone were best. The responses obtained were not commercially significant.

Cuttings of *Azalea kurume benigeri* taken in June gave in 2 months 94 per cent rooting with dust, 71 per cent rooting with indolebutyric acid at 1 milligram per 100 cubic centimeters for 24 hours, and 61 per cent rooting on untreated cuttings.

**Miscellaneous tests.**—Roots of *Rosa manetti* (American) stocks were treated with 3 milligrams of indolebutyric acid for 24 hours and potted. Groups were placed at 50, 55, and 60° F. along with untreated stocks. These temperature groups were each divided into three lots, one lot held 5 days at the specific temperature, one held 10 days, and one 15 days. Observations on the quality of the root systems produced were made 20 days following the removal of the stocks from the three temperature groups. Table 5 shows that untreated stocks possessed better quality root systems than treated stocks.

TABLE 5.—The effect of treating *Rosa manetti* (American) stocks on the quality of the root systems produced

Treatment	Quality of root systems (per cent)								
	Five days in greenhouse			Ten days in greenhouse			Fifteen days in greenhouse		
	Good	Fair	Poor	Good	Fair	Poor	Good	Fair	Poor
Check .....	33	52	14	32	60	7	45	51	4
Indolebutyric acid 3 mg. per 100 cc. ....	20	55	21	24	65	10	31	62	6

Root cuttings of the pink *Bouvardia hybrida* were soaked in 1, 3, and 5 milligrams per 100 cubic centimeters of indolebutyric acid and planted in sand. Observations after 10 weeks showed that 94 per cent of the check cuttings produced shoots. Thirty-six per cent of the 1-milligram group produced shoots, 2 per cent of the 3-milligram, and 0 per cent of the 5-milligram group. The higher the concentration, the greater the bud inhibition.

Tests with treated and untreated chrysanthemum cuttings showed no differences in yield. Growth observations on poinsettias and ageratum revealed no significant differences.

### SUMMARY

Hardwood cuttings did not respond favorably to treatments with growth substances.

Treatment of softwood cuttings of greenhouse and woody ornamental plants and mature cuttings of narrowleaf evergreens with growth substances decreased the time required for rooting. In general, plants difficult to propagate by cuttings were not benefited by treatment to the extent of making the practice commercially feasible.

The quality of the root system produced on treated softwood cuttings was superior to that of comparable untreated cuttings during the period the cuttings were in the bench.

The use of growth substances in the majority of cases caused more roots to be produced over a larger stem area. Apparently no consistent relation existed between the number of roots induced and their length.

The external position of roots on plants which exhibit specific rooting habits was not changed by applications of growth substances.

Treatment of roots of plants gave variable responses, in general caused a decrease in the root and shoot production.

## DATA AND NOTES ON *CINERARIA*

### Varieties and Strains

NICHOLAS ALTER

During the past year the division of floriculture has conducted a variety test on *Cineraria*, using 26 named varieties or strains. The purpose of the test was to gather accurate information on each variety or strain which would aid the grower in selecting those suitable for his particular needs.

### CULTURAL NOTES

All seed was sown August 6, 1938. It was sown broadcast in flats in a sterilized soil mixture of one-third soil, one-third sand, and one-third peat. The small seed was covered very lightly. When the seedlings were large enough to handle, they were pricked off into flats of sterilized compost soil. From the transplant flats the seedlings were potted into 2¼-inch pots. Later they were

potted into 3-inch, and then into 4-inch pots. On December 20, 1938, they were shifted into 5-inch pots in which they were finished. The soil mixture used consisted of three parts silt loam, one part manure, one part sand, and a 4-inch pot of 4-12-4 per  $2\frac{1}{2}$  bushels of soil. After becoming established in 5-inch pots, the plants were fertilized every 10 days with Nitrophoska and ammonium sulfate alternately, 1 ounce per 2 gallons.

Data and notes on each variety are given in table 1.



Fig. 1.—Variations in growing habits of *Cineraria* varieties and strains

TABLE 1.—Characteristics of 26 *Cineraria* varieties and strains observed during February and March, 1939

Variety	Sowing date	Maturing date	Height	Size of flowers	Color	Remarks
No. 1 C.h.m.n. Rose Carmine	Aug. 6, 1938	Feb. 25, 1939	$\frac{1}{n}$ , 17	$\frac{1}{n}$ , 1½	Pale amaranth pink to amaranth pink	Uniformly broad plants with medium-sized light green foliage
No. 2 C.h.m.n. Dark Blue	Aug. 6, 1938	Mar. 10, 1939	15	1½	Bluish violet to blackish violet	Low compact grower, medium-sized dark green foliage
No. 3 C.m.n. Potsdam	Aug. 6, 1938	Feb. 28, 1939	16	1½-2	Cameo pink to dahlia carmine to oxblood red to dark violet	Compact plants with large dark green foliage
No. 4 C.m.n. Maxima	Aug. 6, 1938	Feb. 20, 1939	16	1½-2	Blue violet to amethyst violet to true purple	Large compact raised flower cluster, compact plants with very large light green foliage (see fig. 1, plant 4)
No. 5 C.m.n. Mixed	Aug. 6, 1938	Feb. 25, 1939	16	1-1½	Dark blue violet to hyacinth violet to true purple, all with yellow center	Large compact raised flower cluster, compact plants with medium-sized dark green foliage
No. 5 C.l.f. Azure Blue	Aug. 6, 1938	Feb. 20, 1939	14	2	Light blue violet	Low compact flower cluster, low-spreading plants with very large coarse light green foliage
No. 7 C.l.f. Roseamond	Aug. 6, 1938	Feb. 20, 1939	15	2-2½	Pale Rosolane purple to Chinese violet to blue violet to spectrum violet	Broad petals which roll back from tips, low-spreading plants with very large coarse light green foliage which tends to yellow
No. 8 C.l.f. Dark Blue	Aug. 6, 1938	Feb. 20, 1939	15	2-2½	Dark violet to blackish violet	Low compact flower cluster, low compact plants with large dark green foliage
No. 9 C.h.m.n. Dark Red	Aug. 6, 1938	Mar. 10, 1939	16	1-1½	True purple	Uniformly dense compact plants, medium-sized very dark green foliage
No. 10 C.h.m.n. Rose	Aug. 6, 1938	Mar. 10, 1939	12	1½	Deep rose pink	Low-spreading flower cluster, small and very compact plants with small dark green foliage
No. 11 C.h.m.n. Azure Blue	Aug. 6, 1938	Feb. 28, 1939	18	1½	Violet purple to true purple to dark violet	Large raised flower cluster, tall plants with large dark green foliage (see fig. 1, plant 11)
No. 12 Siter's Rainbow Strain	Aug. 6, 1938	Feb. 25, 1939	16	1-1½	Light mallow purple to eosine pink to deep rose pink to rhodamine purple to true purple, most with dark centers	Broad compact flower cluster, broad plants with large light green foliage

TABLE 1.—Characteristics of 26 *Cineraria* varieties and strains observed during February and March, 1939—continued

Variety	Sowing date	Maturing date	Height <i>In.</i>	Size of flowers <i>In.</i>	Color	Remarks
No. 13 Ericksoni Private Stock	Aug. 6, 1938	Mar. 10, 1939	14-16	1½-1¾	Phlox pink to blue violet, with white eyes; to rhoda- mine purple	Low compact flower cluster, low broad compact plants with large light green foliage
No. 14 C.l.f. Matador	Aug. 6, 1938	Feb. 10-15, 1939	14	2-2½	Carmine	Large raised rounded flower clusters, compact plants, large light green foliage (see fig. 1, plant 14)
No. 15 C.l.f. White	Aug. 6, 1938	Feb. 15, 1939	15	2¼-3¼	White, lavender centers	Dark centers, broad petals which roll back from tips, low, broad, clumsy looking plants with very large coarse yellow (chlorotic) foliage. The large leaves tended to roll upwards from the edges. There was a decided tendency for the foliage to yellow (see fig. 1, plant 15)
No. 16 C.l.f. Crimson	Aug. 6, 1938	Feb. 25, 1939	13	2-3	Phlox pink to true purple	Large low flower clusters, broad low plants, very large coarse dark green foliage
No. 17 James Giants	Aug. 6, 1938	Feb. 20, 1939	14	2½-3	Phlox purple to rhodamine purple to royal purple, most with dark centers and large white eyes	Broad petals which roll back from tips, uniformly low compact plants with very large coarse dark green fol- iage (see fig. 1, plant 17)
No. 18 Feltham Beauty	Aug. 6, 1938	Feb. 25, 1939	16-18	2	Mallow purple to true pur- ple to light bluish violet	Large loose flower cluster, broad plants with very large coarse foliage showing some tendency to yellow
No. 19 C.h.p.	Aug. 6, 1938	Feb. 25, 1939	22	1¼-2	Pale Persian lilac to phlox purple to bluish violet	Large loose flower cluster, broad loose-growing plants with medium-sized light green foliage. Not compact (see fig. 1, plant 19)
No. 20 C.p.s. Blue	Aug. 6, 1938	Feb. 10, 1939	24-26	1½	Blue violet	Raised loose-spreading flower cluster, very tall plants, foliage large and dark green. Not compact, free grow- ing (see fig. 1, plant 20)

TABLE 1.—Characteristics of 26 *Cineraria* varieties and strains observed during February and March, 1939—concluded

Variety	Sowing date	Maturing date	Height <i>I<sub>n</sub></i>	Size of flowers <i>I<sub>n</sub></i>	Color	Remarks
No. 21 C.p.s. Salmon Pink	Aug. 6, 1938	Feb. 20, 1939	26-28	$\frac{1}{2}$	Pale Persian lilac to spinal pink	Narrow petals which roll lengthwise becoming tube- like, raised flower clusters, very tall plants with small and light green foliage which tends to yellow, long internodes. Free growing
No. 22 Improved Hybrids	Aug. 6, 1938	Feb. 28, 1939	14	1½-2	Rhodamine purple, white eye, to aster purple to spectrum violet	Large raised flower cluster, broad compact plants with very large light green foliage (see fig. 1, plant 22)
No. 23 Cremer's Prize Strain	Aug. 6, 1938	Feb. 25, 1939	16-17	1-1½	Pale amparo purple to roy- al purple to true purple	Large raised flower clusters, large compact plants with medium-sized light green foliage (see fig. 1, plant 23)
No. 24 C.m.n. Gold Center	Aug. 6, 1938	Feb. 25, 1939	14-16	¾-1	Light mallow purple to pur- ple to hyacinth violet, all with golden eye	Raised flower cluster, compact plants with medium- sized light green foliage (see fig. 1, plant 24)
No. 25 C. plenissima	Aug. 6, 1938	Mar. 1, 1939	26	2	Light Hortense violet, white edged, to Hortense violet	Completely double flower forming a ball, flower balls drooping in a raised cluster, tall, rangy plants with large light green foliage, long internodes (see fig. 1, plant 25)
No. 26 Howard and Smith's Strain	Aug. 6, 1938	Feb. 20, 1939	17-20	2-5½	Pale violet blue to light plum purple to true pur- ple to mulberry purple	Large spreading plants with very large dark green fol- iage, long wide petals which appear rolled tubelike, later flatten out (see fig. 1, plant 26)

\*Abbreviations: C—*Cineraria*; h—hybrids; m—multiflora; n—nana; l—large; f—flowering; p—petalantha; e—etallata

# THE CONTROL OF CHERRY LEAF SPOT

H. C. YOUNG AND H. F. WINTER

Until 1937 the spray program for the control of cherry leaf spot was thought to be a settled matter. Liquid or dry lime-sulfur was considered the standard material to use, and it was suggested that three applications would control the disease. In 1937 this schedule failed completely and many trees were defoliated by harvest time. Even where the number of applications was increased to six, and with thorough spraying, the disease was not controlled. Similar results were obtained in 1938, and the necessary conclusions are that lime-sulfur cannot be depended upon to control leaf spot during seasons favorable for leaf spot development.

During the seasons in which lime-sulfur was effective there was considerable criticism of its use because it dwarfed the cherry leaves and fruit. It was because of such criticism that a large number of materials were tried as substitutes for lime-sulfur in 1936. Previous to this time many of the wettable sulfurs and flotations were tried, and all were found ineffective in controlling the disease. Bordeaux mixture was also tried and found too injurious to the foliage.

The 1936 experiment included basic copper chloride, copper oxychloride, Coposil, lime-sulfur, many of the wettable sulfurs, including flotation, and a 4-6-100 Bordeaux. The fungicidal effectiveness could not be evaluated because there was no leaf spot on the unsprayed trees. The Bordeaux-sprayed trees were defoliated the latter part of August because of copper injury. The fixed coppers caused only a trace of injury.

A somewhat more extensive experiment was conducted in the same orchard in 1937. The trees were old Early Richmond. The spray applications were made May 19, May 28, June 9, June 24, and July 15. The weather was wet with frequent showers and the temperature high enough for ideal leaf spot development. The materials used and results secured are given in table 1. These results show clearly that lime-sulfur, as well as all other sulfurs, failed to control cherry leaf spot in 1937. All the coppers controlled the disease and, excepting Bordeaux, caused very little injury.

A more uniform orchard of 12-year-old Montmorency trees was selected for the 1938 tests. It was hoped that the trees were sufficiently uniform that leaf area measurements and yield records could be obtained. The spray applications were made May 3 (petal-fall), May 12 (shucks-fall), May 24, June 14, and July 12. Since the fixed coppers controlled so well in 1937 it was thought advisable to try a series of plots with only three applications. These were applied May 12, June 14, and July 12. The materials used, degree of control, and injury are given in table 2.

All the fixed coppers were used with and without a spreader. The results were in general negative, that is, the spreader neither reduced injury nor increased the effectiveness of the copper. Several plots were sprayed with lime-sulfur in the first application, followed with the fixed coppers. No increased injury from copper resulted.

TABLE 1.—Cherry leaf spot control—1937

Materials and amount in 100 gallons	Defoliation by leaf spot August 2	Defoliation by leaf spot September 1	Remarks
Liquid lime-sulfur..... 2 gal.	<i>Pct.</i> 10	<i>Pct.</i> 70	.....
Liquid lime-sulfur..... 1½ gal.	13	70	.....
Liquid lime-sulfur..... 1½ gal. Gelatin..... 2 oz.	25	85	.....
Liquid lime-sulfur..... 1 gal. Gelatin..... 2 oz.	40	85	.....
Liquid lime-sulfur..... 1 gal. Sulfur (wetttable) ..... 5 lb.	15	60	.....
Liquid lime-sulfur ..... 1 gal. Sulfur (dusting) ..... 5 lb. Gelatin..... 1 oz.	15	80	.....
Liquid lime-sulfur..... 1 gal. Sulfur (dusting) ..... 5 lb. Milk, dried skimmed ..... 4 oz.	10	70	.....
Liquid lime-sulfur..... 1 gal. Sulfur (dusting) ..... 5 lb. Gelatin..... ½ oz. Grasselli Spreader ..... ½ oz.	70	95	.....
Sulfur (dusting)..... 10 lb. Gelatin..... ½ oz. Grasselli Spreader..... ½ oz.	90	95	.....
Flotation paste ..... 16 lb.	10	65	.....
Dry lime-sulfur..... 3 lb. Sulfur (dusting)..... 5 lb.	15	50	.....
Bordeaux..... 4-6-100	Trace	Trace	50 per cent of the leaves were off because of copper injury
Bordeaux..... 4-6-100 Metallic zinc..... ½ lb.	Trace	Trace	60 per cent of the leaves were off because of copper injury
Cupro-K..... 6 lb.	Trace	Trace	Very slight injury
Cupro-K..... 4 lb.	Trace	2	Very slight injury
Cupro-K..... 4 lb. Flour (wheat)..... 4 lb.	Trace	2	Very slight injury
Cupro-K..... 4 lb. Bentonite..... 5 lb.	Trace	2	Very slight injury
Cupro-K..... 3 lb.	1	5	No injury
Coposil..... 4 lb.	5	15	Moderate injury
Coposil..... 4 lb. Bentonite..... 5 lb.	5	5	Moderate injury
Check ..... No spray	85	100	.....

The evidence obtained from these plots indicates clearly that all the sulfur combinations failed to control leaf spot again in 1938. The early part of the season was wet, but from June until September almost normal weather prevailed. Leaf spot was late in starting, but even under this condition the sulfurs failed. On the other hand, almost all the fixed coppers and Bordeaux gave excellent control. Even a 1-2-100 Bordeaux controlled leaf spot.

The fixed coppers caused too much injury when used without lime. With lime they were effective and safe. All the copper compounds gave excellent control with but three applications.

TABLE 2.—Cherry leaf spot control—1938

Materials and amount in 100 gallons*	Defoliation by leaf spot August 1	Defoliation by leaf spot September 15	Injury July 15	Injury September 15	
	<i>Pct.</i>	<i>Pct.</i>			
T-26..... 3 lb.	0	0	Moderate	Moderate	
T-34..... 2¼ lb.	0	Trace	Moderate	Moderate	
T-tribasic..... 1½ lb.	0	0	Severe	Severe	
T-26, three applications only . 3 lb.	0	Trace	Moderate	Slight	
T-26..... 3 lb.	}	Trace	Slight	None	
Hydrated lime ..... 3 lb.					
T-tribasic..... 1½ lb.	}	Trace	Slight	Slight	
Hydrated lime ..... 3 lb.					
Cupro-K ..... 3 lb.	0	Trace	Slight	Slight	
Cupro-K, three applications only ..... 3 lb.	0	5	None	Slight	
Cupro-K ..... 2 lb.	Trace	10	None	Slight	
Cupro-K, three applications only ..... 2 lb.	5	20	None	Slight	
Cupro-K ..... 3 lb.	}	Trace	None	None	
Hydrated lime ..... 3 lb.					
Basicop..... 3 lb.	}	0	None	Trace	
Hydrated lime ..... 8 lb.					
Basicop..... 2 lb.	0	0	Moderate	Severe	
Basicop..... 1½ lb.	0	0	Moderate	Moderate	
Basicop..... 2 lb.	}	0	Moderate	Moderate	
Hydrated lime—in first appli- cation only ..... 2 lb.					
G. C. C. .... 1¾ lb.	0	Trace	Moderate	Moderate	
G. C. C. .... 2 lb.	0	0	Severe	Moderate	
G. C. C. three applications only ..... 1¾ lb.	0	Trace	Moderate	Moderate	
Liquid lime-sulfur ..... 2 gal.	5	30	Severe leaf scorching from post-harvest spray Moderate leaf scorching from post-harvest spray		
Liquid lime-sulfur..... 1½ gal.	5	40			
Liquid lime-sulfur ..... 1 gal.	}	80			
Catalytic sulfur..... 5 lb.					
Catalytic sulfur..... 8 lb.	10	80			
Homemade catalytic sulfur.... 8 lb.	10	60			
Camden flotation paste ..... 16 lb.	5	50			
Belle flotation paste..... 16 lb.	Trace	15			
Ultrafine ..... 12 lb.	Trace	25			
Bordeaux..... 1-2-100	0	Trace	Trace	Trace	
Bordeaux..... 2-1-100	0	0	Severe	Moderate	
Bordeaux..... 2-3-100	0	0	Slight	Moderate	
Bordow ..... 6 lb.	0	Trace	Moderate	Moderate	
Bordeaux 34..... 2 lb.	0	Trace	Moderate	Moderate	
Coposil ..... 3 lb.	0	Trace	Severe	Moderate	

\*T—Basic copper sulfate, Tennessee Copper Company.  
G. C. C.—Grasselli basic copper chloride.

Leaf measurements showed that lime-sulfur stunted leaves over 25 per cent as compared with the copper compounds. This factor alone is sufficient reason to eliminate the use of lime-sulfur in cherry spraying. No fruit measurements could be made because of the very severe freeze of May 12.

### CONCLUSIONS

The sulfurs failed when disease was severe. The standard material, lime-sulfur, not only failed to control disease but also dwarfed the leaves. The copper compounds controlled the disease and when used with lime were safe. Three pounds of a fixed copper (based on 25 per cent metallic) and 3 pounds of hydrated lime in 100 gallons of water make a safe and effective spray for sour cherries.

## OATS, PEAS, AND FLAX AS A COMBINATION CROP

### Part I. Possibilities as a Dairy Ration

C. F. MONROE AND C. C. HAYDEN

A combination of grains that could be grown, harvested, threshed, ground, and fed together as a complete grain ration for dairy cows would appear to be desirable. One of the attractive features of such a crop is that it would enable the farmer to produce his own grain feed, which presumably would be more economical than purchasing it. Some unforeseen difficulties and some uncontrollable irregularities may be encountered, however, to render such a procedure impractical as well as unreliable. With these points in mind a combination crop of oats, peas, and flax was tried.

On two different occasions this crop was grown and fed to dairy cows as the entire grain mixture. Although the amounts of the different grains in the crop varied somewhat, both years the mixture contained over 16 per cent of protein. The chief difference between the crops of the 2 years was the amount of peas and weed seeds which it contained. In the first year's crop there were more peas and weed seeds than in the second. Flaxseed formed a small part of the mixture in both years, a little over 5 per cent. Oats comprised the greater part of the mixture, averaging 67 per cent. The composition of the mixtures in the 2 years is shown in table 1.

TABLE 1.—Composition of combination crops  
Per cents by weight

	First year	Second year
Oats.....	70.7	63.3
Peas.....	9.0	21.6
Flax.....	6.5	5.4
Oat hulls, weed seeds, dust, etc. ....	13.8	9.7
Total protein, per cent.....	16.6	17.8

In both years this home-grown crop was compared with the same check grain mixture. The check grain mixture averaged close to 16 per cent of total protein and was composed of the following: ground yellow corn, 400 pounds; ground oats, 300 pounds; old-process linseed meal, 200 pounds; wheat bran, 100 pounds; and salt, 10 pounds. The oats-peas-flax mixture was ground, and 1 per cent of salt was added, but no other grains. In other words, the combination grain was fed practically the way it came from the threshing machine.

Second-cutting alfalfa hay of rather poor quality was fed in both trials. The first year the cows received corn silage in addition, but in the second year no silage was fed. The hay was fed more liberally in the second year to make up for the lack of corn silage.

The results of the two trials are shown in table 2.

**TABLE 2.—Average production per month, with liveweight gains and feed consumption**

Ration	Milk Lb.	Fat Pct.	Fat Lb.	4 per cent milk Lb.	Live- weight gain Lb.	Grain Lb.	Hay Lb.	Corn silage Lb.
First year—seven Holsteins, one Jersey								
Oats, peas, flax .....	765.2	3.74	28.6	735.1	23	270	331	688
Check .....	772.6	3.69	28.5	737.0	10	269	332	674
Second year—six Holsteins, ten Jerseys								
Oats, peas, flax .....	680.4	4.58	31.2	740.1	15	263	564	.....
Check .....	681.6	4.47	30.5	730.9	10	268	562	.....
Average—both years								
Oats, peas, flax .....	722.8	4.14	29.9	737.6	19	267	562	.....
Check .....	727.1	4.06	29.5	734.0	10	269	560	.....
Difference .....	—4.3	.08	.4	3.6	9	—2	2	.....

The results of the two trials are almost identical. In both, there was but very little difference in the production from the two grain mixtures. The consumption of feed was nearly the same on both rations each year. In both trials, however, there was slightly more gain in liveweight on the oats-peas-flax mixture than on the check mixture. In the first trial this difference amounted to 13 pounds for each cow per month, but in the second this difference was only 5 pounds. In both trials the cows on the oats-peas-flax mixture tested slightly higher than those on the check ration. For the first trial this difference amounted to 0.05 per cent, and in the second it was 0.11 per cent. In general, these results indicate that the two grain mixtures were nearly equal in feeding value.

At the bottom of table 2 the averages for the two trials are given. For purposes of comparison, the silage weights given for the first trial have been converted into equivalent hay weights and averaged. The average figures further emphasize the equality in feeding value of the two grain mixtures.

In the first trial, after the first two periods were finished there was a sufficient amount of the oats-peas-flax mixture remaining to permit continuing the feeding to some of the cows. Hence the rations were again changed, and the work was extended a third period with four cows. The summary for the three periods is shown in table 3.

**TABLE 3.—Average production per month, with liveweight gains and feed consumption**

Four cows in third period

	Milk	Fat	Fat	4 per cent milk	Liveweight gain	Grain	Hay	Corn silage
	<i>Lb.</i>	<i>Pct.</i>	<i>Lb.</i>	<i>Lb.</i>	<i>Lb.</i>	<i>Lb.</i>	<i>Lb.</i>	<i>Lb.</i>
Oats, peas, flax .....	852.3	3.48	29.7	786.4	+9	287	348	713
Check .....	872.7	3.44	30.0	799.1	-6	295	349	713

The additional period did not materially change the results. The differences shown in table 3 for the three periods with the four cows are much like those shown in table 2 for the eight cows in two periods. The differences are not considered significant.

It seemed that the cows did not relish the oats-peas-flax mixture as they did the check mixture. The lack of palatability was evidenced by the lack of eagerness shown by the cows for this feed. At the level of grain feeding followed in this work, however, the possible lack of palatability was not reflected in the amounts of grain eaten.

In order to obtain more definite information on palatability, animals were allowed to eat the grain mixtures free choice. Weighed amounts of the two feeds were placed in buckets held in racks, and the animals were given the opportunity of choosing their grain feed. Results of this test are shown in table 4.

**TABLE 4.—Palatability trial**

Animal No.	Description	Days of test	Total amount of each feed offered Lb.	Amounts of feed eaten	
				Check mixture Lb.	Peas-flax-oats Lb.
First year					
500	Holstein heifer.....	14	56	46.4	20.9
503	Jersey heifer.....	12	29	21.6	11.1
Second year					
419	Jersey cow.....	43	193	153.6	110.8
421	Jersey cow.....	43	193	179.5	158.0
512	Holstein heifer.....	43	193	144.1	151.9

The check mixture was preferred by four of the five animals used in these trials. Only one animal ate more of the oats-peas-flax mixture than she did of the check ration, and the amount of the difference was small. All five animals ate sufficient amounts of the combination mixture to indicate that this feed had at least a fair degree of palatability.

## DISCUSSION

As a dairy feed, the combination crop of oats, peas, and flax has merit. This has been demonstrated in the feeding trials just described. The amount and quality of the mixture produced call for careful consideration. In this work the results were obtained with crops having a sufficient amount of peas and flax to ensure an adequate protein content. In practice this requirement may not always be met, and the subsequent results in feeding will be disappointing. The evaluating of the protein content of the mixture then presents a practical difficulty in the use of this mixture. Of course the problem could be solved by having protein analyses made of the mixture. Also, the mixture could be separated into its component parts and the amount of each grain determined; from this information a fair estimate could be made of the protein content.

Another uncertainty in feeding such a combination crop may be encountered in the lack of uniformity in the feed. In other words, one batch ground for feeding may contain considerably more peas and flax than the next. This lack of uniformity could come from the difference in the stand in the field. If, however, care is used in seeing that the grain from different parts of the field is mixed in threshing and storing, this difficulty can be largely overcome. All the handling operations, such as threshing, storing, grinding, and feeding, assist in mixing the feed.

Feeding the combination crop as the entire grain mixture may be neither desirable nor practical on many farms. Especially may this be true on those farms where corn can be grown to advantage. On these farms the oats, peas, and flax crop may be fed with corn and bran and, if necessary, some high-protein supplement. Thus this crop may be grown and used for adding more protein to a ration than would be possible with an ordinary crop of oats. It is logical to assume that satisfactory results would be obtained in this way in view of the good results obtained when the combination crop was fed by itself.

In these trials and in the discussion the writers have been concerned primarily with the merits of the combination grain crop as a feed for dairy cows. This represents only one part of the problem, however. The other part is the growing of the crop, for in the final analysis, the success of the crop will depend upon its production.

## Part II. Growing the Mixture

L. E. THATCHER

The practice of growing various mixtures of oats, barley, spring wheat, and field peas to be harvested for grain is common in Ontario, Canada, and to a lesser extent in New York State and Michigan. In experiments at the Ontario

Agricultural College (1) a mixture of oats and barley yielded higher than these crops grown separately on the same land area as the mixture and mixed after threshing. In general, the addition of spring wheat, field peas, or flax to the barley-oats mixture reduced the total yield. The Michigan Agricultural Experiment Station reports (2) that the oats and barley mixture was most desirable from the standpoint of yield and total digestible nutrients per acre. The addition of field peas to oats or barley or to the oats-barley mixtures invariably reduced the total yield.

Flax is sometimes grown in mixture with spring wheat, oats, or barley in the flaxseed-producing areas of Minnesota, the Dakotas, and Montana. The mixture of wheat and flax is easily separated so that the crop can be marketed as relatively pure grain. Oats-flax and barley-flax mixtures are not so easily separated except with special machinery and are, therefore, sometimes used for feeding to livestock.

For a number of years inquiries have been received at the Ohio Agricultural Experiment Station from Ohio farmers regarding the desirability of some of these mixtures for use in this State. In order to answer these inquiries the Station started some experiments with various mixtures in 1923. The 5-year results were published in 1928 (3). The only mixture that seemed to offer any superiority over the straight cereal crops was the one of barley and flax, and its superiority was based on the calculated feeding value per acre.

None of the mixtures equaled oats in yield of grain per acre. Oats alone outyielded barley alone in a 10-year test and the mixture of oats and barley was intermediate in yield.

The crop of barley and flax consisted of 92.8 per cent barley and 7.2 per cent flax by weight. Mr. Robison of the Department of Animal Industry fed the ground mixture to one lot of hogs, supplementing it with tankage, ground alfalfa, and minerals. To another lot he fed a similar mixture in which linseed meal was used in an amount to supply as much protein as the flaxseed. The hogs receiving the ground flaxseed made slightly greater gains per day and cost slightly less per 100 pounds of gain than did the linseed meal lot (4).

Experiments were continued during 1928 to 1934, inclusive, in which field peas were grown with oats and harvested for grain. The yields of the mixtures were less than those of oats alone, but the percentage of protein in the mixture was higher than that in oats. These results led to the decision to grow a mixture of oats, peas, and flax in sufficient quantity to supply the Dairy Department with enough of the mixture for a feeding trial with dairy cows. The results of that feeding experiment are reported in the first section of this article.

Table 1 gives the yields of oats, oats and peas, oats and flax, and oats, peas, and flax in the mixture experiment. The crops of 1934 and 1935 were fed to dairy cattle.

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1. Forty years' experiments with grain crops. 1929. Ontario Agr. Coll. Bull. 332.
  2. Crop mixture trials in Michigan. 1934. Mich. Agr. Exp. Sta. Sp. Bull. 256.
  3. Mixtures of spring cereals and flax in Ohio. 1928. Ohio Agr. Exp. Sta. Bull. 421.
  4. Swine feeding experiments with fall pigs. 1929. Ohio Agr. Exp. Sta. Sp. Cir. 17.

TABLE 1.—Yields of oats, peas, flax, and mixtures—Wooster

Crop	Rate of seeding Bu. per acre	Number of years tested	Yield per acre Lb. of grain	Yield relative to oats alone
Oats	2	6*	1,700	100.0
Oats peas	1½ each	6*	915 400	
			Total 1,315	77.4
Oats	2	5†	2,072	100.0
Oats flax	1½ ¼ to ½	5†	1,424 183	
			Total 1,607	77.5
Oats	2	1 (1934)	1,290	100.0
Oats peas flax	1 1 1	1 (1934)	815 90 65	
			Total 970	75.3
Oats	2	1 (1935)	1,880	100.0
Oats peas flax	1 ¾ ¾	1 (1935)	1,028 351 88	
			Total 1,467	78.0

\*1928 and 1930 to 1934 inclusive.

†1923-1927 inclusive.

The mixtures yielded from 77.4 to 78.0 per cent less grain per acre than did oats alone. In the 6-year test of oats versus oats and peas, the peas on the average made up 30.5 per cent of the mixture but varied greatly from year to year, ranging from about 10 to 50 per cent. In the 5-year test of oats versus oats and flax, the mixtures contained on the average 11.4 per cent flax, ranging from 3.4 to 18 per cent. The oats, peas, and flax mixture in 1934 contained 9 per cent peas and 6.5 per cent flax and in 1935, 21.6 per cent peas and 5.4 per cent flax.

The oats, peas, and flax mixture was sown in 1936 and 1937 also. The crop was successfully harvested in 1936 but was spoiled by wet weather before it could be threshed. In 1937, a heavy growth of weeds came in before harvest and much lodging took place also. Attempts were made to harvest the crop by mowing and raking and by means of the combine harvester but were abandoned as unsuccessful. The crop was lost.

The various mixtures of oats, peas, and flax proved to be unsatisfactory from the culture standpoint because (a) the yields were too low compared with oats, (b) the proportion of each grain in the mixture varied too widely from year to year, and (c) weeds and lodging interfered with harvesting.

If enough oats are sown to keep weeds under control, the yield of peas and flax will be severely reduced. If oats are sown thin enough for the growth of the peas and flax, weeds are likely to be troublesome, especially if the rainfall is favorable to weed growth.

# **COTTONSEED MEAL FOR GROWING AND FATTENING PIGS IN DRY LOT**

**W. L. ROBISON**

## **UNTREATED COTTONSEED MEAL AS ONLY PROTEIN CONCENTRATE INJURIOUS**

When it is fed under dry lot conditions and used in sufficient quantities to supply the protein needed to balance corn, cottonseed meal is often injurious to growing and fattening pigs.

Differences of opinion have existed as to the cause or causes of the harmful effects from feeding cottonseed meal to pigs. Among earlier suggestions of possible causes of the injurious effects of cottonseed meal were: an excess of acid-forming over base-forming elements, the oil present in the meal, the fiber or lint in it, unsaturated fatty acids, decomposition products, nitrogenous materials, and certain compounds of phosphorus.

More recently one group of workers has concluded that the proteins of cottonseed meal are of high quality and that the trouble arises from feeding the meal in rations that are deficient in vitamins and minerals. Another group has reported that the inadequacy of the proteins is the causative factor and that the gossypol in the seed, which is recognized as toxic, is changed to a bound, insoluble, or harmless, form during the process of manufacturing the meal. A third group does not claim that the proteins of cottonseed meal are completely adequate for optimum results, that there is no deleterious effect if cottonseed meal is used in deficient rations, or that all of the ill effects that may be encountered are necessarily due to gossypol. This group is of the opinion that unless something is done to overcome its harmful effect, gossypol, or some constituent of many cottonseed meals, is definitely injurious and that even when such meals are used in rations which provide ample quantities of the various essential nutrients this constituent is still detrimental.

Protein concentrates of plant origin are deficient in minerals and in vitamin D. Fairly good results are obtained, however, even under dry lot conditions, when suitable inorganic minerals and from 3 to 5 per cent of green, leafy, sun-cured alfalfa or other leguminous hay are fed in connection with yellow corn and such protein concentrates as linseed or soybean oil meal.

In seven dry lot trials pigs that were carried from approximately 55 to 190 pounds in weight and fed linseed meal with yellow corn and minerals gained 0.94 pound daily a head and consumed an average of 433 pounds of feed per 100 pounds of gain produced. In two other trials in which ground alfalfa was also included in the ration the pigs made an average gain of 1.08 pounds daily and required 416 pounds of feed per 100 pounds of gain produced.

In 11 dry lot trials, pigs that were carried from approximately 60 to 200 pounds in weight and fed yellow corn, soybean oil meal, and minerals, gained 1.12 pounds daily a head and required 405 pounds of feed per 100 pounds of gain produced. In four other dry lot trials, pigs that were carried from 54 to 210 pounds in weight and fed yellow corn, soybean oil meal, ground alfalfa, and minerals, gained 1.21 pounds daily a head and required 392 pounds of feed per 100 pounds of gain produced.

Feed mixtures composed of white corn or small grains and tankage or plant protein concentrates are deficient in vitamin A. From 3 to 5 per cent of good quality leguminous hay improves such a ration by supplying vitamin A as well as vitamin D and other nutrients.

Since rations of linseed meal or soybean oil meal combined with yellow corn, alfalfa, and minerals are not so seriously deficient in minerals and vitamins as to prevent them from being fairly effective, the chances are that rations of cottonseed meal, a feed of somewhat similar character, combined with corresponding amounts of the same feeds are not either.

Since 1928, 11 dry lot experiments with as many different shipments or lots of hydraulic or standard cottonseed meals have been carried on at the Ohio Experiment Station. These included 14 groups of pigs. Rations of yellow corn, cottonseed meal, ground alfalfa, and minerals were fed. The losses sustained in each of the experiments are shown in table 1.

With the exception of the 36 per cent protein cottonseed meal fed one group of pigs in the experiment started July 1, 1930, the cottonseed meals contained approximately 41 per cent of protein. The cottonseed meals for lots 3 and 5 in the experiment started July 6, 1938, were cooked with steam under pressure before the oil was pressed out.

Cod-liver oil made up 0.5 per cent of the ration fed lot 3 in the experiment started May 3, 1933.

Gossypol determinations of the cottonseed meals used in some of the experiments were made by Dr. J. O. Halverson of the North Carolina Experiment Station. These gossypol contents were as follows:

Experiment started	Expeller cottonseed meal		Hydraulic cottonseed meal		Prepressure cooked hydraulic cottonseed meal	
	Ether extractable	Total	Ether extractable	Total	Ether extractable	Total
Dec. 7, 1932 .....				0.08		
Dec. 12, 1934 .....	0.04	0.82	0.06	1.06		
Jan. 1, 1936 .....	.07	1.14				
July 6, 1938 .....	.15	1.52	.31	1.59	0.25	1.59

Except in one in which there were no deaths in a group of eight pigs, the mortality was not less than 37.5 per cent in any one of the 11 experiments. Out of a total of 124 pigs, 66 died. This is an average death loss of 53.2 per cent. The cottonseed meals for the meal fed lot 3 in the experiment started July 6, 1938, were cooked with steam under pressure before the oil was pressed out. Those for the meal for lot 1 in the same experiment were not. Both meals were made from the same supply of cottonseed. Dr. J. O. Halverson of the North Carolina Experiment Station reported them higher in gossypol than any other meals he had analyzed for gossypol content. With these two groups omitted, the average death loss was 46.2 per cent.

#### HARMFULNESS NOT OVERCOME BY SUPPLYING VITAMIN A

Conclusive evidence that a deficiency of vitamin A was not responsible for the injurious effect of such rations was provided in different ways.

In one of the experiments a group of pigs that had been fed a vitamin A deficient ration composed of white corn, cottonseed meal, tankage, minerals, and cottonseed oil containing a vitamin D concentrate began showing the effects

TABLE 1.—Deaths among pigs in dry lot fed cottonseed meals with yellow corn, ground alfalfa, and minerals

Experiment started	Lot	Cottonseed meal in ration, per cent			Approximate protein in ration, per cent			Pigs	Deaths	Average death loss, per cent	
		Growing period	Fattening period	Average	Growing period	Fattening period	Average				
Hydraulic cottonseed meals											
Dec. 18, 1928...	1	18.0	12.5	16.2	14.9	13.1	14.3	8	5	53.2	
Dec. 18, 1928...	2	18.0	12.5	14.5	14.9	13.1	13.8	8	3		
Dec. 18, 1928...	3	18.0	12.5	15.0	14.9	13.1	13.9	8	3		
Dec. 18, 1928...	4	18.0	12.5	15.5	14.9	13.1	14.1	8	4		
June 26, 1929...	3	21.2	21.2	21.2	15.7	15.7	15.7	10	5		
Jan. 7, 1930...	2	20.0	16.0	18.2	15.5	15.5	15.0	9	4		
July 1, 1930...	2	20.0	15.7	19.0	15.5	15.5	15.2	8	5		
Dec. 7, 1932...	4	18.4	18.4	18.4	15.0	15.0	15.0	8	3		
May 3, 1933...	3	22.0	16.6	19.1	16.0	16.0	15.2	8	3*		
Aug. 9, 1933...	1	17.0	12.0	13.6	14.6	14.6	13.5	8	0		
Dec. 20, 1933...	1	19.5	14.0	18.3	15.4	15.4	15.0	8	6		
Dec. 12, 1934...	1	19.0	13.5	17.0	15.4	15.4	14.6	13	7		
July 6, 1938...	1	19.5	15.0	18.1	15.4	15.4	14.9	10	9		
July 6, 1938...	3	19.5	15.0	18.7	15.4	15.4	15.1	10	9		
Hydraulic cottonseed meals, moistened and autoclaved for one-half hour											
Jan. 7, 1930....	1	20.0	16.0	17.8	15.5	14.3	14.8	9	2	23.5	
July 1, 1930....	1	20.0	15.7	18.3	15.5	14.1	15.0	8	2		
Hydraulic cottonseed meals, moistened and autoclaved for 1 hour											
June 26, 1929...	8	21.2	21.2	21.2	15.7	15.7	15.7	10	0	0	
Dec. 7, 1932....	5	18.4	18.4	18.4	15.0	15.0	15.0	8	0		
Hydraulic cottonseed meals, 20 per cent of ration, but with tankage											
July 1, 1930....	1	20.0	20.0	20.0	19.9	19.9	19.9	8	0	0	
Jan. 13, 1931...	1	20.0	20.0	20.0	19.9	19.9	19.9	12	0		
Apr. 22, 1931...	1	20.0	20.0	20.0	19.9	19.9	19.9	9	0		
Hydraulic cottonseed meals, treated with a solution of iron sulfate											
Aug. 9, 1933...	2	17.0	12.0	13.6	14.6	13.0	13.5	8	0	0	
Dec. 20, 1933...	2	19.5	14.0	17.6	15.4	13.8	14.8	8	0		
Dec. 12, 1934...	3	19.0	19.0	19.0	15.4	15.4	15.4	13	0		
July 6, 1938...	2	19.5	15.0	16.9	15.4	14.0	14.6	10	0		
July 6, 1938...	4	19.5	15.0	17.0	15.4	14.0	14.6	10	0		
Expeller cottonseed meals											
June 26, 1929...	4	21.2	21.2	21.2	15.7	15.7	15.7	10	1		13.0
Jan. 7, 1930....	3	20.0	16.0	18.0	15.5	14.3	14.9	9	2		
July 1, 1930....	6	20.0	15.7	18.0	16.0	14.1	14.9	8	0		
Dec. 7, 1934...	6	18.4	18.4	18.4	15.0	15.0	15.0	8	0		
Dec. 12, 1934...	2	19.0	13.5	16.7	15.4	13.9	14.5	13	4		
Jan. 1, 1936...	6	19.0	14.6	16.6	15.4	14.0	14.6	11	0		
July 6, 1938...	5	19.5	15.0	16.8	15.4	14.0	14.6	10	2		
Expeller cottonseed meals, treated with a solution of iron sulfate											
Dec. 12, 1934...	4	19.0	19.0	19.0	15.4	15.4	15.4	12	0	0	
Jan. 1, 1936...	5	19.0	14.6	16.3	15.4	14.0	14.5	11	0		
July 1, 1936...	1	19.0	14.6	16.8	15.4	14.0	14.6	9	0		
Dec. 1, 1936...	7	19.6	14.5	16.7	15.6	14.0	14.5	13	0		
July 6, 1938...	6	19.5	15.0	17.0	15.4	14.0	14.6	10	0		
Expeller cottonseed meal, 36 per cent protein											
July 1, 1930....	11	25.0	20.0	23.1	16.0	14.5	15.3	8	5	62.5	

\*Cod-liver oil made up 0.5 per cent of the ration.

of a lack of vitamin A after having been on feed from 24 to 31 weeks. The symptoms observed were impaired vision, muscular incoordination, a lack of muscular tone, a staggering gait, and a pronounced swaying or drooping of the back. When yellow corn was substituted for the white corn and cod-liver oil for the cottonseed oil and vitamin D concentrate, the vitamin A deficiency symptoms disappeared and fairly normal growth took place.

The usual symptoms of cottonseed meal injury were a loss of appetite, a general listlessness, an anemic appearance, thumping, or labored breathing, and eventually death. In Bulletin 410 of the Texas Experiment Station, Dr. R. C. Dunn gives the following macroscopic lesions as post-mortem findings in cottonseed meal poisoning: "pleural and peritoneal cavities, excessive quantities of serous fluid; heart, dilated and flabby; lungs, congested and edematous; liver, enlarged and passive congested; spleen, congested; kidneys, congested; lymph glands, when affected, congested and swollen."

In experience at the Ohio Station large quantities of an amber-colored serous fluid in the peritoneal and pleural cavities, and inflammation of the blood vessels of the intestines and mesentery have been characteristic post-mortem symptoms.

Both the ante- and post-mortem symptoms of cottonseed meal injury were distinct from those of avitaminosis A.

Cod-liver oil was fed along with yellow corn, cottonseed meal, ground alfalfa, and minerals to one of the 14 groups previously mentioned. Although this ration undoubtedly contained an abundance of vitamin A it produced the characteristic effects of cottonseed meal feeding. Three pigs out of eight in the group died.

## METHODS OF OVERCOMING THE INJURIOUS EFFECT

**Moistening and autoclaving.**—Moistening and autoclaving, or cooking with steam, under 14 pounds of pressure for 1 hour destroyed the toxicity of the cottonseed meals or reduced it to such an extent that no deaths occurred in two trials with a total of 18 pigs fed yellow corn, cottonseed meal, ground alfalfa, and minerals. Untreated meals from the same supplies fed in similar rations caused the deaths of 5 out of 10 and 3 out of 8, or a total of 8 out of 18 pigs.

In two other trials moistening cottonseed meal and cooking it with steam under 14 pounds of pressure for one-half hour reduced the death losses from 9 out of 17 to 4 out of 17, or from 53 to 23.5 per cent, but did not make it entirely safe.

Unless something other than a vitamin A deficiency were responsible for the injurious effect, it could not have been reduced or overcome by simply moistening and cooking the cottonseed meal with steam under pressure and adding no vitamin A to the ration.

**Treating with iron sulfate solution.**—In December 1915, after Withers of the North Carolina Experiment Station, with Brewster and Carruth, had reported that a solution of iron was beneficial in diminishing or averting the toxic effect of cottonseed meal, a group of five pigs was started on tankage and two others of equal numbers on cottonseed meal as supplements to yellow corn. Salt, limestone, and ground rock phosphate, in separate containers, were kept before each group of pigs. The other feeds were fed twice daily. Two per cent as much dry ferrous sulfate as cottonseed meal was mixed with the feed for one of the groups fed cottonseed meal. Shortly before feeding time, a solution

containing a pound of ferrous sulfate to each 50 gallons of water was used, at the rate of 1 gallon to each pound of cottonseed meal, to moisten the feed for the third lot. Water only, in equivalent amounts, was used to moisten the feed for the first two.

Four pigs out of five fed the ration to which dry ferrous sulfate was added died by the end of the eighth week of the experiment. Two deaths occurred on the thirty-first, one on the fifty-first, and one on the fifty-third day of the experiment.

On the twenty-eighth day a pig that succumbed to spasms or tremors was removed from lot 3. None of the pigs in lots 1 and 3 died during the 14 weeks they were continued on feed.

Further tests to study the influence of a ferrous sulfate or copperas solution in overcoming the injurious effect of cottonseed meal to pigs were started in 1933. Five comparisons of untreated and iron-treated hydraulic cottonseed meals and three comparisons of untreated and iron-treated expeller cottonseed meals have been made. In one comparison with each type of meal the cottonseed meats were cooked with steam under pressure before the oil was removed. Iron-treated expeller cottonseed meal was also fed in trials started July 1 and December 1, 1936, in which it was not compared with untreated meal. The number of pigs in each lot at the beginning and the number that died during the course of the experiment are shown in table 1. The summarized data for the experiments comparing untreated and iron-treated hydraulic and untreated and iron-treated expeller cottonseed meals are given in table 2.

In one experiment with both hydraulic and expeller cottonseed meals, in order to put the treatment to a more exacting test, the iron-treated meals were fed at the rate of 19 per cent of the total feed throughout the test, whereas the untreated meals were reduced from 19 to 13.5 per cent of the total feed when the pigs averaged 120 pounds in weight. With this exception the cottonseed meals were fed at levels ranging from 17 to 19.5 per cent of the total feed until the pigs averaged 120 pounds in weight and from 12 to 15 per cent thereafter. The total protein in the rations ranged from 14.6 to 15.4 per cent during the growing period and from 13 to 14 per cent during the fattening period.

The death losses among the pigs that were fed the untreated hydraulic cottonseed meals in the five comparisons were: no pigs out of 6, 6 out of 8, 7 out of 13, 9 out of 10, and 9 out of 10, respectively. In the trial in which there were no deaths, dry iron sulfate made up 5 per cent of the added minerals or one-eighth of 1 per cent of the total feed. With this exception the minerals consisted merely of salt, limestone, and bone meal. The results of this trial are reported in table 9 of Ohio Experiment Station Bulletin 534.

An average of 3.4 pounds of iron sulfate in solution to each 100 pounds of cottonseed meal was used in the five comparisons. In the experiment started July 6, 1938, although 9 out of 10 pigs in lot 3 fed the untreated standard hydraulic cottonseed meal died, 2 pounds of iron sulfate, in solution, mixed with each 100 pounds of cottonseed meal, were effective in preventing losses.

The death losses among the pigs fed untreated expeller cottonseed meals in the three comparisons were 4 out of 13, 0 out of 11, and 2 out of 10, respectively.

Out of a total of 49 pigs fed iron-treated hydraulic and of 55 fed iron-treated expeller cottonseed meals, not a single one died. Since they lived and since less cottonseed meal was fed during the fattening than during the growing period, the percentage fed the pigs on the iron-treated meals sometimes averaged a little less than that fed the pigs on the untreated meals.

TABLE 2.—Effect of treating cottonseed meal with a solution of ferrous sulfate for pigs

	1	2	1	2
	Untreated hydraulic cottonseed meal	Iron-treated hydraulic cottonseed meal	Untreated expeller cottonseed meal	Iron-treated expeller cottonseed meal
Ground yellow corn, ground alfalfa, minerals				
Average percentage of cottonseed meal.....	16.5	16.9	16.7	17.5
Number of comparisons.....	5	5	3	3
Pigs at start.....	49	49	34	33
Initial weight per pig, lb.....	55.0	55.5	57.0	59.1
Pigs at close.....	18	48	27	33
Number of deaths.....	31	0	6	0
Final weight per pig, lb.....	201.7	202.6	195.7	205.5
Average daily gain, lb.....	.49	.93	.74	1.03
Days to gain 160 lb.....	326	172	217	156
Daily feed per pig, lb.:				
Ground corn.....	2.31	3.26	3.02	3.55
Cottonseed meal.....	.49	.72	.66	.81
Ground alfalfa.....	.12	.16	.16	.19
Mineral mixture.....	.07	.10	.09	.11
Iron sulfate.....	.....	.02	.....	.01
Total.....	2.99	4.26	3.93	4.67
Feed per 100 lb. of gain, lb.:				
Ground corn.....	468.67	348.23	408.88	344.79
Cottonseed meal.....	100.22	76.67	88.77	79.13
Ground alfalfa.....	23.39	17.29	21.26	18.10
Mineral mixture.....	14.85	11.02	12.56	10.58
Iron sulfate.....	.....	2.25	.....	1.42
Total.....	607.13	455.46	531.48	454.03
Cost of feed per 100 lb. of gain, dollars.....	7.85	5.94	6.87	5.91
Value a pound with untreated meal at 1.6 cents, cents.....	.....	4.09	.....	2.82
Value with untreated meal as 100 per cent, per cent.....	.....	255.8	.....	176.2

Minerals, except as noted: salt, 20; pulverized limestone, 40; special steamed bone meal, 40.

Shelled corn 63 cents a bushel, tankage \$2.50, linseed meal \$1.90, cottonseed meal \$1.60, soybean oil meal \$1.60, ground alfalfa 90 cents, minerals \$2.00, iron sulfate \$3.00, dried skim-milk \$4.60, grinding corn, 10 cents for 100 pounds. Costs and values in all tables are based on these prices.

That a solution of iron sulfate overcame the toxicity is further evidence that something other than a deficiency of vitamin A is responsible for the harmfulness resulting from feeding some cottonseed meals to pigs.

### TANKAGE REDUCED INJURIOUS EFFECT

Tankage exerted a protective influence. When cottonseed meals which at the same or slightly lower levels caused death losses made up 20 per cent of the ration but 8 per cent of tankage was also included, no deaths occurred. In the one instance in which a direct comparison was made, five out of eight pigs fed an equivalent amount of cottonseed meal but no tankage died. In the other two instances cottonseed meals which had proved toxic at corresponding levels in previous experiments were used. In practice, if some tankage were included, the cottonseed meal in the ration would be reduced and a further factor of safety thus introduced.

The ability of tankage to reduce the toxicity of cottonseed meal without the amount fed being cut down is additional evidence that something other than a deficiency of vitamin A is involved in cottonseed meal injury.

### FEEDING VALUE OF COTTONSEED MEALS INFLUENCED BY TECHNIQUE OF MANUFACTURE

Untreated hydraulic and untreated expeller cottonseed meals were compared for feeding with yellow corn, ground alfalfa, and minerals in six dry lot experiments. The pigs were full-fed twice daily in four, and self-fed in two of the comparisons. The two types of meals for the various experiments were made from the same supplies of seed, so that they differed only in the process of manufacture. In so far as possible the pigs were carried from approximately 50 to 200 pounds in average weight. Table 3 summarizes the results secured.

TABLE 3.—Comparisons of hydraulic and expeller cottonseed meals

	Untreated		Iron treated		Combined with tankage	
	1	2	1	2	1	2
	Hydraulic cottonseed meal	Expeller cottonseed meal	Hydraulic cottonseed meal	Expeller cottonseed meal	Hydraulic cottonseed meal	Expeller cottonseed meal
Ground yellow corn, ground alfalfa, minerals						
Average percentage of cottonseed meal.....	19.0	19.1	19.0	19.0	8.3	8.3
Number of comparisons.....	6	6	1	1	4	4
Pigs at start.....	58	58	13	12	35	35
Initial weight per pig, lb.....	48.1	47.3	52.5	52.9	49.5	49.3
Pigs at close.....	27	48	12	12	34	33
Number of deaths.....	31	9	0	0	0	0
Final weight per pig, lb.....	193.1	202.6	189.9	202.3	199.2	204.8
Average daily gain, lb.....	.61	.53	.58	.57	.57	1.06
Days to gain 160 lb.....	264	193	182	165	166	152
Daily feed per pig, lb.:						
Ground corn.....	2.46	2.96	3.02	3.02	3.50	3.74
Tankage.....					.27	.30
Cottonseed meal.....	.62	.74	.77	.77	.36	.38
Ground alfalfa.....	.09	.10	.16	.16	.13	.14
Mineral mixture.....	.08	.10	.10	.10	.09	.10
Iron sulfate.....			.01	.01		
Total.....	3.25	3.90	4.06	4.06*	4.35	4.66
Feed per 100 lb. of gain, lb.:						
Ground corn.....	404.76	356.13	342.13	311.31	361.96	353.88
Tankage.....					28.40	28.11
Cottonseed meal.....	101.50	89.71	87.26	79.40	37.44	36.59
Ground alfalfa.....	15.51	12.45	18.37	16.71	13.51	13.23
Mineral mixture.....	13.24	11.62	11.48	10.45	9.39	9.14
Iron sulfate.....			1.38	1.25		
Total.....	536.01	460.91	460.62	419.12	450.70	440.95
Cost of feed per 100 lb. of gain, dollars.....	6.99	6.14	6.02	5.48	6.20	5.93
Value a pound with hydraulic meal at 1.6 cents, cents.....		2.54		2.28		1.95
Value with hydraulic meal as 100 per cent, per cent.....		158.8		142.7		121.8

\*The feed was limited to the same amount as that taken by lot 1. If it had been supplied, the pigs would have eaten more feed and, doubtless, as a consequence, would have made more rapid gains.

Thirty-one out of fifty-eight pigs fed the untreated hydraulic meals and nine out of an equal number fed the untreated expeller cottonseed meals died during the course of the experiments. The mortality was, thus, 53 per cent on the hydraulic and 16 per cent on the expeller meals. In the six experiments the death losses on the hydraulic meals were 5 out of 10, 4 out of 9, 5 out of 8, 3 out of 8, 7 out of 13, and 9 out of 10, respectively. The death losses on the expeller meals were 1 out of 10, 2 out of 9, 0 out of 8, 0 out of 8, 4 out of 13, and 2 out of 10, respectively.

The pigs fed the expeller meals made more rapid gains and were ready for market 71 days earlier, on the average, than those fed the hydraulic meals. With the other feeds valued at the prices given, with the hydraulic meal at \$32 a ton, and with only the saving in feed per unit of gain considered, the expeller meal was worth \$50.80 a ton, or 58.8 per cent more than an equal weight of hydraulic meal.

Expeller and hydraulic cottonseed meals which were treated with a solution of iron sulfate to overcome any toxic effect they may have had were compared for feeding with yellow corn, ground alfalfa, and minerals to pigs in dry lot in only one experiment. The pigs fed the expeller meal were limited to the same amount of feed as that taken by the pigs fed the hydraulic meal. If given an opportunity they would have taken more feed and doubtless as a consequence made faster gains. There were no deaths in either group. Even when limited to the same amount of feed, the pigs fed the iron-treated expeller meal were ready for market 17 days earlier than those fed the iron-treated hydraulic meal. As determined from the feed saved per unit of gain, the expeller meal, under these conditions, was worth 42.7 per cent more a pound than hydraulic meal made from the same supply of seed.

Four dry lot experiments were conducted in which untreated hydraulic and untreated expeller cottonseed meals, combined with tankage and fed with yellow corn, ground alfalfa, and minerals, were compared. In one, 6 pounds of cottonseed meal to 4 of tankage, in two, equal quantities of each, and in the fourth, 2 pounds of cottonseed meal to 1 of tankage were used. These quantities averaged approximately 30 per cent more cottonseed meal than tankage.

As would be anticipated, the advantage of expeller over hydraulic cottonseed meal was not as great under these conditions as when cottonseed meal was used as the only protein concentrate in the ration. The pigs that received expeller cottonseed meal, however, ate a little more feed, were ready for market 14 days earlier on the average, and required 9.75 pounds less feed per 100 pounds of gain than those that received hydraulic cottonseed meal. There were no deaths. When only the feed per unit of gain is considered, the expeller meal was worth 21.8 per cent more than the hydraulic meal for feeding with tankage in this way.

Mixtures of standard, that is, untreated hydraulic, cottonseed meals and tankage in ratios of 2:1, 1:1, and 1:2 were compared with a mixture of linseed meal, 1, tankage, 2, for feeding with yellow corn, ground alfalfa, and minerals to pigs that were confined indoors.

TABLE 4.—Different amounts of hydraulic cottonseed meal with tankage for pigs in dry lot

	Cottonseed meal, 2 tankage, 1		Cottonseed meal, 1 tankage, 1		Cottonseed meal, 1 tankage, 2	
	Linseed meal	Cottonseed meal	Linseed meal	Cottonseed meal	Linseed meal	Cottonseed meal
Cottonseed meal to tankage		2:1		1:1		1:2
Average percentage of cottonseed meal		10.4		6.8		3.7
Number of comparisons	1	1	2	2	3	3
Pigs at start	8	8	16	17	28	28
Initial weight per pig, lb.	60.7	59.7	50.8	50.4	52.8	52.3
Pigs at close	8	7	16	17	26	26
Final weight per pig, lb.	212.1	206.3	208.0	198.8	221.9	216.3
Average daily gain, lb.	1.20	.84	1.02	.92	1.24	1.17
Days to gain 160 lb.	134	190	157	174	129	137
Daily feed per pig, lb.:						
Ground yellow corn	3.95	3.29	3.62	3.48	4.09	4.02
Tankage	.45	.22	.40	.29	.37	.35
Linseed meal	.22		.20		.18	
Cottonseed meal		.43		.29		.17
Ground alfalfa	.15	.13	.13	.13	.16	.15
Minerals	.13	.10	.08	.09	.06	.06
Total	4.90	4.17	4.43	4.28	4.86	4.75
Feed per 100 lb. of gain, lb.:						
Ground yellow corn	328.80	390.54	354.76	376.44	330.07	342.89
Tankage	37.44	25.71	38.79	31.69	29.70	29.65
Linseed meal	18.72		19.39		14.85	
Cottonseed meal		51.41		31.69		14.83
Ground alfalfa	12.21	14.83	13.02	13.86	12.55	12.75
Minerals	10.99	11.86	7.96	9.21	4.72	4.89
Total	408.16	494.35	433.92	462.89	391.89	405.01
Cost of feed per 100 lb. of gain, dollars	5.65	6.62	5.96	6.22	5.28	5.45
Value of cottonseed meal a pound, cents		— .29		.78		.82

Pigs fed twice, equally, and half as much untreated hydraulic cottonseed meal as tankage were ready for market 57, 17, and 8 days later, respectively, and, in the order named, required 21.1, 6.7, and 3.3 per cent more feed per 100 pounds of gain than similar pigs fed half as much linseed meal as tankage. Twice as much untreated hydraulic cottonseed meal as tankage was fed in only one trial. Although the findings are not regarded as conclusive, they indicate that at the higher levels untreated hydraulic cottonseed meal exerted some detrimental effect in spite of the presence of tankage in the ration.

With feeds at the prices given and with only the amounts of the various feeds consumed per unit of gain considered, untreated hydraulic cottonseed meal was worth 43 per cent as much a pound as linseed meal, in the three experiments in which each was fed at the rate of 1 pound to every 2 pounds of tankage.

**TABLE 5.—Comparison of cottonseed meal and linseed meal for feeding with tankage**

(Experiments at other stations included)

	1 Corn Tankage Linseed meal Ground alfalfa Minerals	2 Corn Tankage Cottonseed meal Ground alfalfa Minerals
Average percentage of cottonseed meal .....	.....	3.8
Tankage to cottonseed or linseed meal .....	2:1	2:1
Number of comparisons .....	11	11
Pigs at start .....	108	109
Initial weight per pig, lb. ....	61.5	61.4
Pigs at close .....	106	106
Final weight per pig, lb. ....	216.3	212.2
Average daily gain, lb. ....	1.43	1.37
Days to gain 160 lb. ....	112	117
Daily feed per pig, lb.:		
Corn .....	4.85	4.68
Tankage .....	.44	.43
Cottonseed or linseed meal .....	.22	.21
Ground alfalfa .....	.21	.21
Minerals .....	.03	.02
Total .....	5.75	5.55
Feed per 100 lb. of gain, lb.:		
Corn .....	338.90	341.12
Tankage .....	31.11	30.93
Cottonseed or linseed meal .....	15.55	15.46
Ground alfalfa .....	14.95	15.20
Minerals .....	1.74	1.68
Total .....	402.25	404.39
Cost of feed per 100 lb. of gain, dollars. ....	5.39	5.37
Value of cottonseed meal a pound, cents .....	.....	1.76
Value with linseed meal as 100 per cent, per cent .....	.....	92.5

Table 5 summarizes the three Ohio and eight other experiments in which linseed and cottonseed meals were compared for feeding at the rate of 1 pound to every 2 pounds of tankage to pigs in dry lot. The pigs fed cottonseed meal required 5 days more time to fit them for market than those fed linseed meal. As determined from the feed required per unit of gain, the average worth of the cottonseed meal was 92.5 per cent that of the linseed meal. This is a more favorable showing for untreated hydraulic cottonseed meal than was obtained in the three Ohio trials, but older and heavier pigs were used in some of the other experiments.

A protein concentrate consisting of equal parts of iron-treated hydraulic cottonseed meal and tankage and one consisting of equal parts of linseed meal and tankage were compared in an experiment reported in table 6.

TABLE 6.—Comparisons of iron-treated cottonseed meals and linseed meal for feeding with tankage to pigs in dry lot

	A		B	
	1	2	1	2
	Tankage and linseed meal	Tankage and iron-treated hydraulic cottonseed meal	Tankage and linseed meal	Tankage and iron-treated expeller cottonseed meal
Ground yellow corn, ground alfalfa, minerals				
Average percentage of cottonseed meal.....		6.2		7.0
Tankage to linseed or cottonseed meal.....	1:1	1:1	1:1	1:1
Number of comparisons.....	1	1	2	2
Pigs at start.....	14	14	24	22
Initial weight per pig, lb.....	58.1	58.8	59.8	60.6
Pigs at close.....	13	14	23	21
Final weight per pig, lb.....	225.1	217.6	212.8	211.6
Average daily gain, lb.....	1.47	1.42	1.39	1.30
Days to gain 160 lb.....	109	113	116	124
Daily feed per pig, lb.:				
Ground yellow corn.....	4.99	4.93	4.56	4.32
Tankage.....	.42	.37	.42	.37
Linseed meal.....	.42		.43	
Cottonseed meal.....		.37		.38
Ground alfalfa.....	.25	.24	.23	.22
Mineral mixture.....	.09	.09	.06	.06
Iron sulfate.....		.01		.01
Total.....	6.17	6.01	5.70	5.36
Feed per 100 lb. of gain, lb.:				
Ground yellow corn.....	339.58	347.61	328.63	332.89
Tankage.....	28.55	26.15	30.64	28.86
Linseed meal.....	28.55		30.64	
Cottonseed meal.....		26.15		28.87
Ground alfalfa.....	16.79	16.93	16.44	16.48
Mineral mixture.....	6.30	6.51	4.57	4.90
Iron sulfate.....		.52		.52
Total.....	419.77	423.87	410.92	412.52
Cost of feed per 100 lb. of gain, dollars.....	5.69	5.63	5.61	5.53
Value of iron-treated cottonseed meal a pound, cents.....		1.85		1.91
Value of iron-treated cottonseed meal with linseed meal as 100 per cent, per cent.....		97.2		100.6

The differences in feed consumption, rate of gain, and gain per unit of feed consumed were small. The pigs fed the iron-treated hydraulic cottonseed meal were ready for market 4 days later than those fed the linseed meal. The value of the iron-treated hydraulic cottonseed meal was 97.2 per cent that of the linseed meal. Although twice as much was fed, this is an even better comparative showing for cottonseed meal than was made in the 11 experiments reported in table 5.

The results of two experiments comparing iron-treated expeller cottonseed meal with linseed meal for feeding with an equal amount of tankage are also given in table 6.

Early in one of the tests a pig was removed from each lot. Exclusive of these pigs and one fed cottonseed meal which gained 71.5 against an average of 170.3 pounds for his pen mates, the pigs fed linseed meal and those fed iron-treated expeller cottonseed meal required 115 and 118 days, respectively, to make an average gain of 160 pounds.

Iron-treated expeller cottonseed meal was worth fully as much a pound as linseed meal when both were fed with equal weights of tankage.

### **IRON-TREATED EXPELLER COTTONSEED MEAL WITH OTHER PROTEIN CONCENTRATE AN EFFECTIVE SUPPLEMENT**

The results of an experiment which was previously reported in Ohio Experiment Station Bulletin 452 and in which a mixture of equal parts of untreated hydraulic cottonseed meal and soybean oil meal was compared with one of tankage, 2, linseed meal, 1, for feeding with yellow corn, ground alfalfa, and minerals to pigs in dry lot are presented in table 7. There was practically no difference in any respect in the performance of the pigs in the two lots.

Representative results may not have been obtained in the single trial, but unless these results were unusually favorable they indicate the possibility of a combination of cottonseed meal and soybean oil meal providing an effective and economical protein concentrate. Presumably the iron-treated expeller cottonseed meal would be preferable with soybean oil meal, just as it is with tankage.

An experiment comparing a protein concentrate consisting of 1 pound of dried skimmilk to each 5 pounds of iron-treated hydraulic cottonseed meal and one consisting of equal parts of tankage and linseed meal is reported in table 7.

Although they hardly equalled the performance of the others, the pigs that received the iron-treated hydraulic cottonseed meal and dried skimmilk made a satisfactory showing.

The results of a similar comparison except that in it iron-treated expeller cottonseed meal was used are also given in table 7. The pigs that received the iron-treated expeller cottonseed meal and dried skimmilk took less feed daily a head and 8 days more time to make an average gain of 160 pounds in weight but required slightly less feed per 100 pounds of gain produced than those that received tankage and linseed meal.

TABLE 7.—Cottonseed meal combined with other protein concentrates than tankage

	With soybean oil meal		With dried skim milk			
	1	2	1	2	1	2
	Tankage and linseed meal	Hydraulic cottonseed meal and soybean oil meal	Tankage and linseed meal	Iron-treated hydraulic cottonseed meal and dried skim milk	Tankage and linseed meal	Iron-treated expeller cottonseed meal and dried skim milk
Ground yellow corn, ground alfalfa, minerals						
Average percentage of cottonseed meal.....		7.9		14.6		13.9
Other supplement to cottonseed meal.....		1:1		1:5		1:5
Number of comparisons.....	1	1	1	1	1	1
Pigs at start.....	13	13	14	14	11	11
Initial weight per pig, lb.....	53.3	52.8	58.1	58.0	61.4	62.8
Pigs at close.....	11	12	13	14	11	11
Final weight per pig, lb.....	215.3	217.6	212.5	206.9	215.5	226.4
Average daily gain, lb.....	1.15	1.15	1.45	1.33	1.57	1.46
Days to gain 160 lb.....	139	139	111	121	102	110
Daily feed per pig, lb.:						
Ground corn.....	3.85	3.65	4.86	4.26	5.07	4.44
Tankage.....	.41		.41		.45	
Linseed meal.....	.21		.42		.45	
Dried skim milk.....				.16		.16
Soybean oil meal.....		.36				
Cottonseed meal.....		.37		.82		.81
Ground alfalfa.....	.14	.14	.24	.23	.25	.23
Mineral mixture.....	.07	.12	.09	.14	.12	.15
Iron sulfate.....				.02		.02
Total.....	4.68	4.64	6.02	5.63	6.34	5.81
Feed per 100 lb. of gain, lb.:						
Ground corn.....	333.80	317.77	335.77	321.06	322.63	304.12
Tankage.....	35.41		28.59		28.42	
Linseed meal.....	17.71		28.59		28.42	
Dried skim milk.....				12.31		11.05
Soybean oil meal.....		31.90				
Cottonseed meal.....		31.90		61.57		55.26
Ground alfalfa.....	12.15	12.13	16.63	16.91	16.12	15.86
Mineral mixture.....	6.08	10.51	6.24	10.77	7.34	10.17
Iron sulfate.....				1.23		1.59
Total.....	405.15	404.21	415.82	423.85	402.93	398.05
Cost of feed per 100 lb. of gain, dollars.....	5.54	5.23	5.65	5.89	5.49	5.51

# THE COMPARATIVE VALUE OF EXPELLER AND TOASTED SOLVENT SOYBEAN OIL MEALS FOR CHICKS<sup>1</sup>

R. M. BETHKE AND M. C. SWEET

That properly processed soybean oil meal is a satisfactory protein supplement for poultry has been shown by many investigators. Pioneering work in this connection was that of Phillips, Carr, and Kennard (1), who reported in 1920 that soybean oil meal gave results comparable to those obtained with meat scraps in chick rations provided that adequate minerals were used. Since then many reports (2, 3, 4, 5, 6, 7, 8, 9, 10, 11) have appeared in the literature concerning the value and place of soybean oil meals in poultry feeding. The findings in general have shown that properly heat-processed soybean oil meals may be used successfully as one of the primary sources of protein in poultry rations. On the other hand, whole or ground soybeans have proved unsatisfactory.

Most of the soybean oil meals available at the present time are produced by either the "expeller" or the "solvent-extracted" method. In the expeller process, sufficient heat is applied in the extraction of the oil to impart a toasted odor and flavor to the meal. This type of meal has been found satisfactory for poultry feeding. In the "solvent" method of extracting the oil the temperature is not sufficiently high to give the meal that palatable toasted taste and odor, and the meal has been found lower in feeding value for poultry and swine than properly processed expeller meal. Investigators at the Wisconsin Station (7) and at Cornell (8) have reported, however, that a solvent-extracted meal which had been cooked for 15 minutes at 98° C. gave results comparable to those obtained with good expeller meals in feeding trials with chicks. Unpublished results at the Ohio Station have shown that properly heat-processed solvent-extracted soybean oil meal is equal in feeding value to expeller soybean oil meal for pigs.

The present experiment was undertaken to obtain further information on the comparative feeding value of "expeller" and "heat-processed solvent-extracted" soybean oil meals for poultry. The experiment involved a comparison of three series of rations containing the two types of soybean oil meals.

<sup>1</sup>This work was made possible through the financial support of the Central Soya Company, Ft. Wayne, Indiana.

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In one set of rations (Nos. 1 and 2) the soybean oil meals served as the only source of supplemental protein. A second set of rations (Nos. 3 and 4) contained 5 per cent of dried skimmilk in addition to the two types of soybean oil meals. The third pair of rations (Nos. 5 and 6) compared the two types of soybean oil meals when used with dried skimmilk, meat scraps, and fish meal as the protein supplement. The details of the rations are shown in table 1.

TABLE 1.—Composition of experimental rations

Ingredients	Rations					
	1	2	3	4	5	6
Ground yellow corn	45.0	47.6	44.2	46.4	47.6	48.9
Wheat middlings	15.0	15.0	15.0	15.0	15.0	15.0
Wheat bran	10.0	10.0	10.0	10.0	10.0	10.0
Expeller soybean oil meal	25.0		20.8		12.9	
Toasted solvent soybean oil meal		22.4		18.6		11.6
Dried skimmilk			5.0	5.0	5.0	5.0
Meat scraps					3.0	3.0
Fish meal (menhaden)					3.0	3.0
Steamed bone meal	2.0	2.0	2.0	2.0	.5	.5
Ground limestone	1.0	1.0	1.0	1.0	1.0	1.0
Salt	1.0	1.0	1.0	1.0	1.0	1.0
Cod-liver oil	1.0	1.0	1.0	1.0	1.0	1.0

Manganese sulfate was added to all rations at the rate of 6 grams per 100 pounds of ration.

Synthetic riboflavin was incorporated in all rations at the rate of 300 micrograms per 100 grams of ration.

The total protein content was approximately 18 per cent in all the rations. Sufficient riboflavin (vitamin G) was added to all rations (300 micrograms per 100 grams) to meet the requirements of the chick for this factor. The soybean oil meals used were commercial grades manufactured by the Central Soya Company and obtained from a local dealer. The expeller meal analyzed 41.6 per cent protein and the toasted solvent-extracted meal, 46.4 per cent protein. The latter meal was toasted or heat-processed after solvent extraction

Each ration was fed to two separate groups of 25 White Leghorn chicks each. The chicks were of the Station's stock and were started on experiment when 1 day old. All groups were confined in brooders equipped with wire grid floors and weighed individually each week. Lights were used to give the chicks an approximate 14-hour day.

The results of the experiment are recorded in table 2. Mortality was not a factor. Four of the chicks on ration 2 (22.4 per cent toasted solvent meal) showed subcutaneous hemorrhagic lesions (vitamin K deficiency) between the third and fifth week. Three of the four affected chicks recovered and one died as a result of hemorrhage. None of these lesions were observed in the chicks on any of the other rations. The chicks receiving the rations containing toasted solvent soybean oil meal were, on the average, from 20 to 31 grams heavier than comparable groups fed rations containing expeller meal. These differences in weight, although not statistically significant, show conclusively that a properly heat-processed solvent-extracted soybean oil meal is comparable in feeding value to an expeller-processed soybean oil meal for chicks.

TABLE 2.—The average weight, feed utilization, and mortality of the chicks on the experimental rations

Ration	Supplements	Females		Males		Average weight of both sexes at 8 weeks	Mortality	Feed required per gram of gain in weight
		Number	Average weight at 8 weeks	Number	Average weight at 8 weeks			
1	Expeller soybean oil meal.....	26	Gm. 464	23	Gm. 540	Gm. 502	Pct. 2	Gm. 3.10
2*	Toasted solvent soybean oil meal.....	19	450	29	594	522	4	3.05
3 }	Expeller soybean oil meal.....	27	533	23	691	612	0	2.97
	Dried skim milk.....							
4 }	Toasted solvent soybean oil meal.....	22	580	28	701	640	0	2.86
	Dried skim milk.....							
5 }	Expeller soybean oil meal.....	22	608	28	724	666	0	2.81
	Dried skim milk.....							
6 }	Meat scraps and fish meal.....	23	640	27	754	697	0	2.76
	Toasted solvent soybean oil meal.....							
	Dried skim milk.....							
	Meat scraps and fish meal.....							

\*Four chicks on this ration showed subcutaneous hemorrhagic lesions. (vitamin K 3.5 g.)  
chicks died.

\*Four chicks on this ration showed subcutaneous hemorrhagic lesions (vitamin K deficiency) between the third and fifth weeks. One of the four affected chicks died.

It is also of interest to note that the inclusion of 5 per cent of dried skim-milk in the rations resulted in significant increases in growth, and that the further replacement of part of the soybean oil meal with meat scraps and fish meal gave additional growth increases. These observations are in general accord with the results of other investigators that some animal protein, such as milk, meat, or fish, should be combined with soybean oil meal protein for optimum results.

### SUMMARY

Expeller and toasted solvent-extracted soybean oil meals were compared on the same protein basis in three different types of rations for chicks. The results showed conclusively that the toasted solvent extracted meal was comparable to the expeller meal in feeding value for chicks.

## MARKET EGG GRADES AS AFFECTED BY HUMIDITY OF FARM EGG STORAGE ROOMS

D. C. KENNAED AND V. D. CHAMBERLIN<sup>1</sup>

Until recently it was supposed that if eggs were gathered frequently, stored in a sufficiently cool room (40 to 60° F.), and marketed regularly twice a week, they would meet the requirements for highest market grades, as far as the 3- or 4-day holding period before marketing was concerned. Because germ development in fertile eggs actually begins at 68° F., a high temperature (over 70° F.) has generally been regarded a primary cause of poor market quality of eggs. Later developments, however, show that under certain conditions humidity may become a factor of no less importance than temperature.

Despite gathering three to four times daily in wire baskets and prompt removal to the cool egg room where they were cooled overnight before being placed in cases, and marketing twice weekly, the Station's eggs graded mostly U. S. Standards instead of U. S. Extras, particularly during cold weather. A number of other patrons of the Wooster Egg Auction have had similar experiences.

That the eggs from a number of poultrymen using the Wooster Egg Auction tended to go from U. S. Extras to U. S. Standards upon the approach of cold weather led to scrutinizing humidity in connection with the different types of egg-holding rooms used. It was found that those poultrymen whose eggs continued as U. S. Extras during cold weather stored their eggs in rooms with comparatively higher degrees of both temperature (50 to 70° F.) and humidity than those whose eggs graded as U. S. Standards. This contention was substantiated later in tests conducted by the Station (table 1).

Test 1 from February 3 to February 24 was for a period in which supplemental moisture was provided in the Station's egg storage room, and 86 per cent of the large eggs qualified as U. S. Extras. Following test 1, the supplemental moisture was discontinued from February 24 to March 3, when all the large eggs went into U. S. Standards. Tests 3, 4, and 5 tell the same story. Since the temperature was comparable in all the tests, it is obvious that U. S. Extras or U. S. Standards were produced at will, irrespective of normal ranges of temperature, by manipulating the humidity in the Station's egg room.

The egg-holding room at the Station would be generally considered to provide favorable conditions for the temporary holding of fresh eggs. It is a northeast corner basement room 14 by 20 feet with the east end about 4 feet below the surface of the ground. The construction, except for windows and door, is concrete. There is little difficulty in maintaining a desirable temperature either winter or summer. The main deficiency is in humidity during cold weather.

The best solution of this problem has been the use of a small, inexpensive (75-cent) nozzle to produce a spray from water under pressure and an 8-inch electric fan to stimulate the circulation of the moist air. The relative degrees of temperature and humidity taken in tests 4 and 5 and the corresponding effect upon the market quality of the large eggs marketed are recorded in tables 2 and 3.

<sup>1</sup>The authors acknowledge the helpful suggestions of Ralph Treat, Manager, Wooster Egg Auction.

TABLE 1.—Grades and prices of market eggs as affected by supplemental moisture in the egg storage room

Date graded 1939	Eggs marketed*		Price per dozen†			Increased returns from extras over standards Dollars
	Extras large Doz.	Standards large Doz.	Extras large Cents	Standards large Cents	Premium per dozen for extras Cents	
Test 1, with supplemental moisture in egg room						
Feb. 3 .....	120	30	23½	21	2½	3.30
Feb. 7 .....	150	30	24½	22½	1¾	2.62
Feb. 10 .....	150	.....	24½	22½	1¾	2.62
Feb. 14 .....	120	.....	22½	21	1¾	2.10
Feb. 17 .....	120	30	23	20	3	3.60
Feb. 21 .....	150	30	21½	20½	1	1.50
Feb. 24 .....	120	30	21	19	2	2.40
Per cent.....	86	14	.....	.....	.....	.....
Increased returns from extras due to supplemental moisture .....						18.14
Test 2, without supplemental moisture in egg room						
Feb. 28.....	.....	120	21	19½	1½	1.80
Mar. 3 .....	.....	120	23½	20	3½	3.90
Per cent.....	.....	100	.....	.....	.....	.....
Loss owing to discontinuation of supplemental moisture.....						5.70
Test 3, with supplemental moisture in egg room						
Mar. 7 .....	150	.....	21½	19	2½	3.37
Mar. 10.....	120	.....	22	18½	3½	3.90
Mar. 14 .....	120	.....	22½	20	2½	2.70
Per cent.....	100	.....	.....	.....	.....	.....
Increased returns from extras due to supplemental moisture .....						9.97
Test 4, without supplemental moisture in egg room						
Mar. 17.....	.....	90	23	19½	3½	3.15
Mar. 21.....	30	60	22½	19½	3½	1.95
Mar. 24.....	.....	90	23½	20	3½	3.15
Mar. 28 .....	.....	120	22½	20½	2	2.40
Per cent.....	7.7	92.3	.....	.....	.....	.....
Loss owing to discontinuation of supplemental moisture.....						10.65
Test 5, with supplemental moisture in egg room						
Mar. 31.....	150	.....	23½	22½	1½	1.87
Apr. 4 .....	90	.....	22½	22	½	.45
Apr. 7 .....	120	30	21½	19½	2½	2.70
Apr. 11.....	150	.....	21½	20½	1	1.50
Apr. 14.....	90	30	21½	18½	2½	2.25
Apr. 18 .....	120	.....	20½	18½	2	2.40
Per cent.....	92.3	7.7	.....	.....	.....	.....
Increased returns from extras due to supplemental moisture.....						11.17

\*By the Ohio Experiment Station at Wooster.

†Average prices paid at Wooster Egg Auction.

Note: All grading done under Federal-State inspection at auction. Inspection means grading 100 eggs from each case.

**TABLE 2.—Temperature and humidity records with and without supplemental moisture and the effect upon grades of eggs marketed**

Date 1939	Temperature and humidity					
	8 a. m.		12 m.		4 p. m.	
	Temper- ature °F.	Humid- ity Pct.	Temper- ature °F.	Humid- ity Pct.	Temper- ature °F.	Humid- ity Pct.
Without supplemental moisture in egg room						
Mar. 15.....	52	50	53	56	52	44
Mar. 16.....	39	40	50	35	53	29
Mar. 17.....	45	31	46	32	46	28
Mar. 18.....	45	29	44	*	43	30
Mar. 19.....	38	32	41	32	42	32
Mar. 20.....	45	44	49	47	49	41
Mar. 21.....	44	40	49	41	48	44
Mar. 22.....	52	40	55	39	52	38
Mar. 23.....	53	35	57	37	58	41
Mar. 24.....	59	41	61	43	62	70†
Average.....	47.2	38.2	50.5	40.2	50.5	36.3
With supplemental moisture in egg room						
Mar. 25.....	59	88	61	90	62	88
Mar. 26.....	59	*	60	90	61	91
Mar. 27.....	51	68	57	66	57	63
Mar. 28.....	44	60	51	54	48	50
Mar. 29.....	45	73	49	73	51	78
Mar. 30.....	53	91	55	88	56	86
Mar. 31.....	51	81	52	84	54	88
Apr. 1.....	48	86	51	92	52	88
Apr. 2.....	46	84	49	86	49	80
Apr. 3.....	43	78	49	72	52	61
Apr. 4.....	48	63	50	60	*	58
Average.....	49.7	77.2	53.0	77.7	54.2	75.5

\*Not recorded.

†Supplemental moisture started at noon. This figure not included in average.

**TABLE 3.—Average temperature and humidity readings and corresponding percentage of U. S. Extras and U. S. Standards**

March 15 to April 4. See table 2.

	With added moisture	Without added moisture	Change
Temperature (°F.).....	52.3	49.4	+ 2.9
Per cent of humidity.....	76.8	38.2	+38.6
Per cent U. S. Extras.....	100.0	7.7	+92.3
Per cent U. S. Standards.....		92.3	-92.3

Later, as the outside temperature became higher, the temperature in the egg room averaged 2.9° F. higher during the period of supplemental moisture, but this was a negligible variation in so far as the quality of the eggs was concerned. During the period of addition of supplemental moisture, the relative humidity averaged 38.6 per cent greater, and all cases inspected were graded as U. S. Extra quality as compared with the grading of 92 per cent U. S. Standards during the previous period without the supplemental moisture. Seldom

can the dollars and cents value of a practical, inexpensive procedure be demonstrated so positively. The use of the 75-cent nozzle, the small electric fan, and about 2,000 gallons of water yielded, on the basis of 8 to 10 cases of large eggs each week, an average of \$22.55 a month increased returns from eggs grading U. S. Extras instead of U. S. Standards on the basis of price registered on the Wooster Egg Auction during February, March, and April. From the point of proper care and storage of the eggs to secure U. S. Extras instead of U. S. Standards, this increase of 20 to 25 dollars in monthly returns from the sale of extras is comparable to that which could be expected from 1,200 to 1,500 layers. Even from a flock of 200 to 250 it should amount to \$3.00 or \$4.00 a month. What is more, once suitable egg-holding facilities are provided, little or no time and expense are involved afterward.

That the problem in the Station's egg storage room was one of humidity rather than temperature was substantiated by the high percentage (74 per cent) of eggs marketed as U. S. Extras during 6 weeks of July and August when high temperature would most likely have been a problem. It was not until September and October that the eggs began to rate mostly U. S. Standards.

Temperature and humidity are often correlative. Cool or cold air has comparatively little affinity or capacity for moisture, whereas warm air has a high affinity and capacity. Temperature becomes a problem in connection with many egg-holding rooms during warm weather. In this connection it is fortunate that so much emphasis is to be placed upon the importance of a high degree of humidity in the egg storage room, since besides insulation, a liberal supply of moisture with restricted ventilation is one of the best means of lowering the inside temperature 10 to 15° F. during warm weather. When water evaporates much heat is absorbed. A high degree of humidity serves two important purposes during warm weather. It protects the eggs against loss of moisture (loss of market quality), and further, it preserves the quality of eggs against heat deterioration by reducing the temperature in the egg storage room.

The effective use of supplemental moisture to reduce the temperature in egg storage rooms is now a common practice. It is the use of supplemental moisture during cold weather or during dry fall weather to prevent the loss of moisture from the eggs before marketing that is just now gaining recognition. Until more definite information becomes available it can be assumed that with a temperature of 50 to 60° F. the humidity should be around 70 per cent and that with a temperature of 60 to 70° F. it should be around 80 per cent.

Under these conditions of temperature and humidity, care must be observed to keep egg rooms clean and to supply adequate air circulation to prevent the growth of mold. Eggs are highly susceptible to the absorption of musty odors. Furthermore, mold may enter through the shell, causing deterioration and black rots. In all instances eggs in a humidified egg room should be placed at least 1 foot above floor level, and on a slatted platform or bench to ensure proper circulation of air.

### TO PROVIDE HUMIDITY

Humidity in the egg room may be provided by natural or artificial means. In general, the natural means would be more applicable to flocks of 200 to 500 layers and the artificial means to larger flocks.

**Natural.**—Storage in a basement room, root cellar, or dugout with an earth floor free of must or moldy material and a dependable supply of moisture is the most frequent and probably the most dependable natural means. An earth floor can be improved by covering with sand, or walkways of concrete or stepping stones can be provided.

**Artificial.**—Artificial means of providing humidity may vary all the way from the use of a simple spray nozzle to complete air conditioning. The floor can be sprinkled with water in such amounts and at such intervals as necessary to provide the desired amount of humidity. Each egg room presents a different set of factors and conditions with which to deal. Hence, the solution of the problem must be that which is best adapted to meet the requirements under a given set of conditions. Moreover, the type of facilities will be largely determined by the quantity of eggs to be stored.

The facilities and equipment needed for best results are water under pressure (25 to 40 pounds), electricity, a spray nozzle, an electric fan, a thermometer, and a moisture gauge.

To observe the temperature, an inexpensive, reasonably accurate thermometer will serve the purpose. A moisture gauge sufficiently accurate can be procured at from \$1.00 to \$3.00, or a combined temperature and moisture gauge can be procured. Artificial refrigeration would seldom be necessary or justified except for large egg storage rooms to serve large-scale commercial egg production.

## SUMMARY

It is obvious that U. S. Extras or U. S. Standards were produced at will, irrespective of normal temperature ranges, by manipulating the amount of dampness in the Station's egg room. During the period of addition of supplemental moisture, the relative humidity averaged 38.6 per cent greater, and all cases inspected were graded as U. S. Extras, compared with the grading of 92 per cent U. S. Standards during the previous period without supplemental moisture. Seldom can the dollars and cents value of a practical, inexpensive procedure be demonstrated so positively.

# FEED SALES IN OHIO

J. I. FALCONER

The Department of Rural Economics has received annually from feed manufacturers since 1929 a report of their feed sales in Ohio. A comparison of these sales for 1938 with those of 1937 and earlier years is given in table 1.

Total sales for 1938 exceeded those for 1937 by over 7 per cent. Soybean meal sales increased in 1938 by over 58 per cent.

TABLE 1.—Estimated total tons and per cent change of commercial feeds reaching the retail trade in Ohio, 1929-1938

Feed	Estimated tons					
	1929	1932	1933	1935	1937	1938
Mixed feeds:						
Dairy feeds .....	128,320	25,214	30,181	40,345	73,030	79,719
Poultry feeds .....	189,139	56,805	68,754	98,489	145,885	159,642
Hog feeds .....	36,758	2,898	6,092	13,901	42,946	42,581
Other mixed feeds .....	24,728	13,332	17,028	16,782	23,904	23,149
Total mixed feeds .....	378,945	98,249	122,055	169,517	285,765	304,891
Unmixed feeds:						
Soybean meal .....			5,206	20,986	22,297	43,303
Cottonseed meal .....	16,708	6,666	8,425	9,648	11,461	10,774
Linseed oil meal .....	24,060	17,099	19,850	16,033	10,254	12,374
Bran .....	59,167	55,066	57,159	43,419	40,493	45,801
Middlings .....	56,431	42,024	55,015	45,831	52,966	49,711
Alfalfa meal .....	4,762	5,507	2,802	3,142	4,349	4,139
Gluten feeds .....	20,257	15,650	21,222	13,267	14,949	16,190
Hominy .....	49,775	11,303	29,517	22,915	12,443	13,373
Tankage .....	8,971	10,434	10,581	10,444	12,910	11,934
Meat scraps .....	12,154	17,389	20,412	23,639	25,154	20,811
Fish meal .....					817	923
Milk products .....	1,736	1,739	3,069	2,950	3,984	4,382
All other feeds .....	35,367	8,695	14,278	28,946	31,946	31,573
Total unmixed feeds .....	289,388	191,572	247,536	241,220	249,023	265,288
Total (all feeds) .....	668,333	289,821	369,591	410,737	534,788	570,179

TABLE 2.—Annual feed sales in Ohio

Year	Total tonnage	Year	Total tonnage
1929 .....	668,333	1934 .....	371,439
1930 .....	566,079	1935 .....	410,737
1931 .....	410,104	1936 .....	514,553
1932 .....	289,821	1937 .....	534,788
1933 .....	369,591	1938 .....	570,179

# INDEX NUMBERS OF PRODUCTION, PRICES, AND INCOME

J. I. FALCONER

Ohio farm land values in the spring of 1939 showed a slight decline from 1938. This decline was doubtless due to the 20 per cent decline in the price of farm products and the 14 per cent decline in agricultural income.

## Trend of Ohio prices and wages, 1910-1914=100

	Wholesale prices, all commodities U. S.	Weekly earnings N. Y. State factory workers	Prices paid by farmers	Farm products prices U. S.	Ohio farm wages	Ohio farm real estate	Ohio farm products prices	Ohio cash income from sales
1913.....	102	.....	101	101	104	100	105	101
1914.....	99	100	100	101	102	102	105	109
1915.....	102	101	105	98	103	107	106	112
1916.....	125	114	124	118	113	113	121	123
1917.....	172	129	149	175	140	119	182	201
1918.....	192	160	176	202	175	131	203	243
1919.....	202	185	202	213	204	135	218	270
1920.....	225	222	201	211	236	159	212	230
1921.....	142	203	152	125	164	134	132	134
1922.....	141	197	149	132	145	124	127	133
1923.....	147	214	152	142	166	122	134	147
1924.....	143	218	152	143	165	118	133	150
1925.....	151	223	157	156	165	110	159	180
1926.....	146	229	155	145	170	105	155	183
1927.....	139	231	153	139	173	99	147	171
1928.....	141	232	155	149	169	96	154	163
1929.....	139	236	153	146	169	94	151	172
1930.....	126	226	145	126	154	90	128	142
1931.....	107	207	124	87	120	82	89	105
1932.....	95	178	107	65	92	70	63	77
1933.....	96	171	109	70	74	59	69	87
1934.....	110	182	123	90	77	63	85	102
1935.....	117	191	125	108	87	66	110	132
1936.....	118	199	124	114	100	71	118	152
1937.....	126	215	131	121	118	75	128	162
1938.....	115	207	122	95	117	76	103	138
1937								
January...	125	209	130	131	104	.....	128	147
February...	126	211	132	127	.....	.....	127	141
March.....	128	218	132	128	.....	75	129	167
April.....	128	219	134	130	118	.....	134	182
May.....	127	219	134	128	.....	.....	135	162
June.....	127	220	134	124	.....	.....	134	162
July.....	128	218	133	125	123	.....	138	174
August.....	128	220	132	123	.....	.....	135	167
September...	128	215	130	118	.....	.....	129	164
October.....	125	214	128	112	127	.....	123	165
November...	122	205	127	107	.....	.....	116	161
December...	119	207	126	104	.....	.....	114	147
1938								
January...	118	201	126	102	115	.....	109	139
February...	116	204	126	97	.....	.....	105	125
March.....	116	205	125	96	.....	76	106	135
April.....	115	204	125	94	116	.....	104	132
May.....	114	201	125	92	.....	.....	104	139
June.....	114	202	124	92	.....	.....	106	136
July.....	115	205	123	95	119	.....	106	157
August.....	114	205	122	92	.....	.....	100	139
September...	114	214	121	95	.....	.....	102	139
October.....	113	212	121	95	119	.....	96	136
November...	113	207	121	94	.....	.....	98	142
December...	112	212	120	96	.....	.....	98	141
1939								
January...	112	211	120	94	115	.....	94	118
February...	112	213	120	92	.....	.....	94	117
March.....	112	218	120	91	.....	74	92	121
April.....	111	.....	120	89	116	.....	91	122





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## Ohio Agricultural Experiment Station

WOOSTER, OHIO, U. S. A.



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# THE WHEAT FIELD SURVEY FOR 1939

J. S. HOUSER

For the past 22 years the entomologists of Ohio have cooperated in an annual survey of the wheat fields of the State for the purpose of determining the status of the principal pests which damage wheat. The usual procedure has been to visit not less than one-third of the counties in the State and in each county surveyed to collect samples of wheat immediately before harvest. From these samples has been determined by actual count the percentage infestation of the more important wheat pests. This great mass of records has enabled the entomologists to forecast from year to year with considerable accuracy when the principal wheat pest of the State, the Hessian fly, threatened. When the survey records for any given year have indicated that Hessian fly infestation was increasing, farmers were so advised. As a result, there is little doubt that the wheatgrowers of the State have been able to avoid losses which otherwise might have cost them, in the aggregate, millions of dollars.

## THE HESSIAN FLY<sup>1</sup>

Hessian fly increased so sharply in abundance this season that it now constitutes a serious menace to the 1940 crop unless the fly-free dates for seeding are observed this fall. Last year the average infestation of all the fields visited in the State was 10 per cent. This year it rose to 20.5 per cent. The accompanying map, figure 1, indicates the percentage of wheat infested with fly in each of the counties surveyed.

It will be observed that the most heavily infested counties are found in the north central part of the State. It is particularly important that growers in those counties where the heavier infestations are indicated should delay seeding until, or perhaps a day or two after, the recommended seeding dates. In counties where lighter infestations occurred this season a sense of security should not prevail, because in many of these counties are occasional fields of fairly heavy infestation which are capable of producing a sufficiently numerous brood of flies this fall to make considerable trouble.

It has been apparent for the last few years that there has been a growing tendency among Ohio farmers to sow wheat earlier than the fly-free date. A possible reason for this situation is that there has come into existence a partial new generation of wheatgrowers since the time of the devastating fly year of 1920. The lesson learned by the growers of that time was so severe that for several years the fly-free dates were generally observed. The younger growers who have not experienced the losses which the fly is capable of causing may well take stock of what befell their elders, and those older growers whose memories may have become a little dulled with the years would do well to recall the great potentialities for harm which they know from experience the Hessian fly possesses.

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<sup>1</sup>*Phytophaga destructor* (Say).

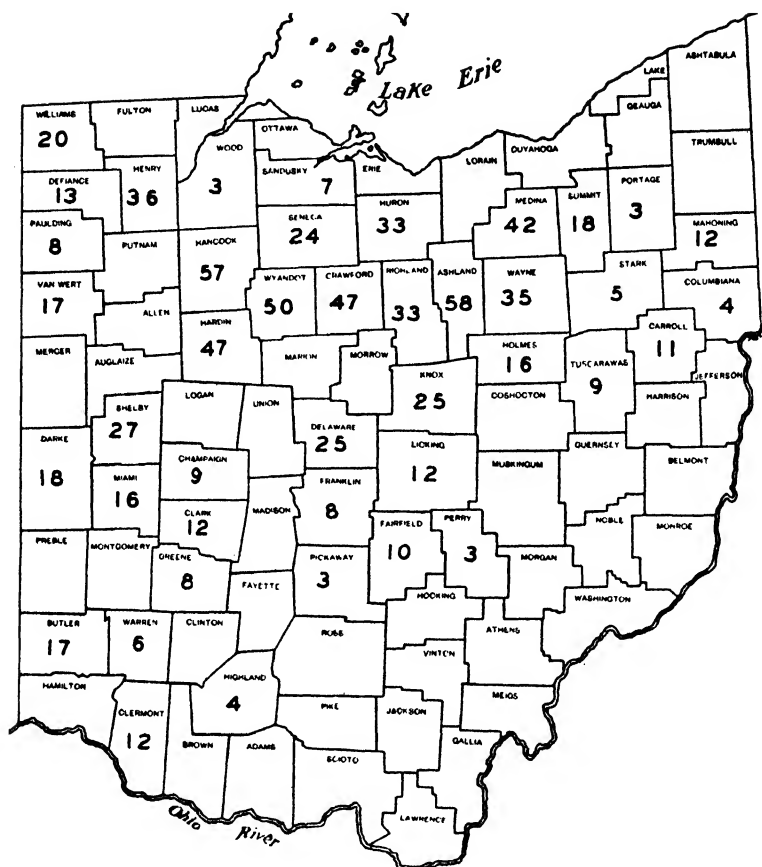


Fig. 1.—The figures indicate the percentage of wheat straws infested with Hessian fly in the counties visited in the 1939 survey.

Average infestation 1938 .....10 per cent  
 Average infestation 1939 .....20.5 per cent

From time to time, as a better understanding of the habits and life history of the fly was revealed by the data which the annual wheat field survey yielded, slight changes have been made in the recommended seeding dates. The dates indicated on the map shown in figure 2 are, we believe, fairly dependable and are strongly suggested for observance this fall.



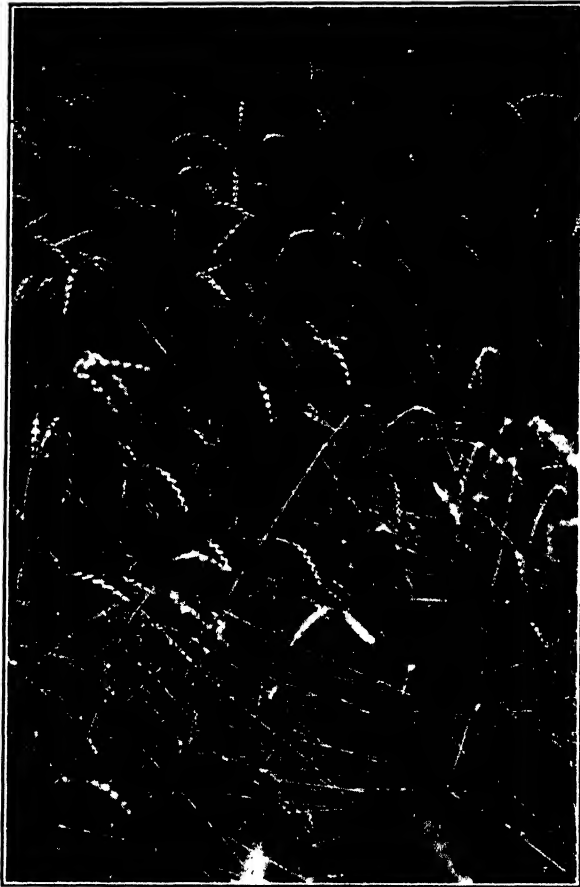


Fig. 3.—A Portage County wheat field sown September 10, 1938, 2 weeks in advance of the fly-free date. Fallen straws are infested with Hessian fly.

### THE BLACK WHEAT-STEM SAWFLY<sup>2</sup>

During the course of the 1934 wheat field survey a new wheat pest, the black wheat-stem sawfly, was found in eastern Ohio. Since that time a careful record has been made each year both of the progress of the insect westward and of the intensity of infestation in the area of known occupancy. This year the insect was found as far west as Richland, Knox, Licking, and Fairfield Counties. Although careful examinations were made in some of the bordering counties to the westward, Delaware, Franklin, and Pickaway, the sawfly had not spread that far.

<sup>2</sup>*Trachelus tabidus* (Fab.).

Figure 4 shows the percentage of wheat infested with sawfly in each of the counties surveyed. It will be noted that this year those counties in which the sawfly is most abundant are located about midway in the infested territory and that the infestation in the older territory which originally was heavily infested has diminished to practical insignificance.

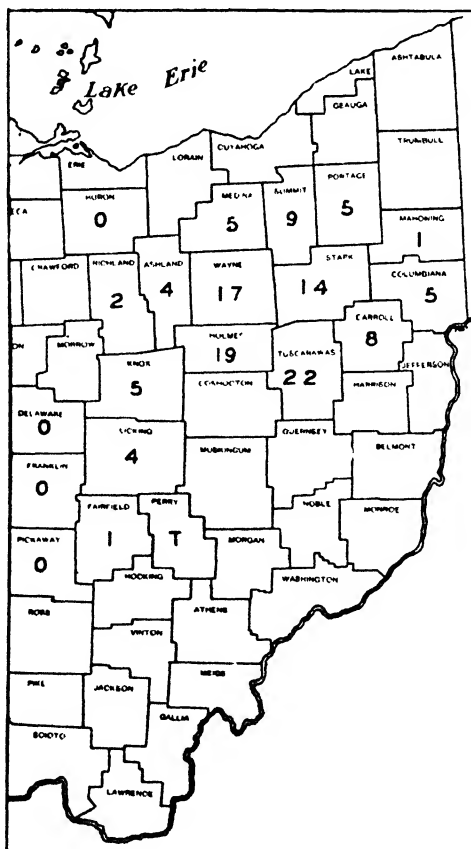


Fig. 4.—The figures in the counties indicate the average percentage of the wheat infested with black wheat-stem sawfly in 1939. The letter T signifies that less than 1 per cent was infested.

It is to be hoped that the behavior pattern of the sawfly to date will hold for the future—that although the insect may become very abundant in newly occupied territory within a relatively short time, the decline in population will be equally rapid.

### THE WHEAT JOINT WORM<sup>1</sup>

During the years 1904 to 1910 inclusive the wheat joint worm was prevalent in Ohio. In 1908 when the outbreak reached its crest, some fields were so severely damaged that they were a total loss and were not harvested. During the ensuing interval little has been seen of the joint worm until it was found this season in significant numbers in the central part of the State. It will be observed in figure 5 that higher infestations were found in Knox and Licking Counties than in any other part of the State.

<sup>1</sup>*Harmolita tritici* Fitch.

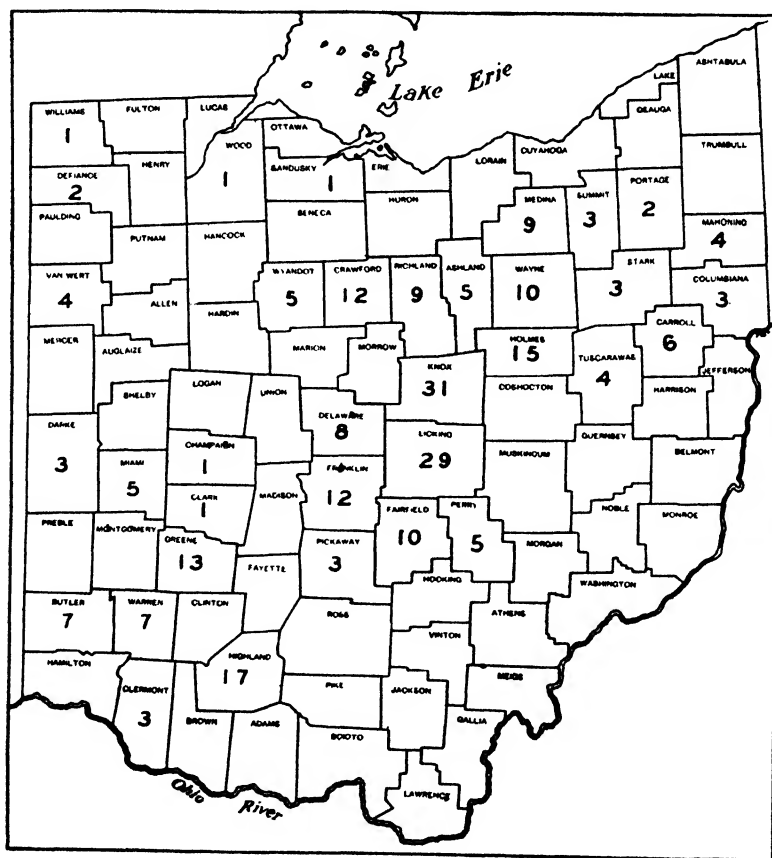


Fig. 5.—The figures indicate the percentage of wheat straws infested with wheat joint worm in the counties in which the insect was found in 1939.

A brief discussion of the joint worm and its work may not be amiss at this time. The winter is passed either in the larval or pupal stage in the field in the walls of the stubble or of fallen straw. About the time the wheat heads emerge the following spring the small black adult appears. It pierces the joint of the straw and deposits an egg therein. The larva which hatches from this egg attacks the straw walls, and an enlargement or gall develops, within which the larva is found. Several such enlargements may adjoin one another to form a compact mass. At the time the enlargements are developing the straw becomes very weak and flexible at the point of injury and the infested plant has a tendency to lodge. After the cells harden the straw becomes very stiff at the point of injury.

When the wheat is threshed, the small, hardened sections of straw are separated with difficulty from the grain. Sometimes the presence of these short sections of straw in the threshed grain is the first evidence the grower detects that something is wrong. A more detailed account of the wheat joint worm may be found in Bulletin 226 of the Ohio Agricultural Experiment Station. This bulletin is still available and will be sent to those who request it.

Inasmuch as this is the first year for a considerable period that the joint worm has been found in significant numbers, it is unsafe to predict the trend the insect may take in 1940 although the chances are that it may increase in abundance. It would seem that the use of the combine would favor the insect, particularly if the straw is scattered at the time of harvest and is allowed to remain in the field.

At the time of the 1904-10 outbreak many farmers resorted to burning the stubble during the winter. It was found that if burning was delayed until winter or very early spring, little if any harm was done the clover. If the burning was done on a community scale, the belief prevailed that damage to the wheat crop was reduced.

Experimental data collected 30 years ago seemed to indicate that good cultural practices and the generous use of commercial fertilizer likewise aided in reducing losses. Date of seeding is of little merit in circumventing damage from joint worm. Stiff-strawed varieties of wheat attacked by joint worm are less likely to lodge than are weak-strawed sorts.

# TREND OF MOTOR TRANSPORTATION RATES FOR LIVESTOCK

GEORGE F. HENNING

Transporting livestock by truck is the accepted method in Ohio today. Some livestock is moved by railroads to or from more distant points, but the bulk is given a ride on rubber tires. Since the volume of movement is so important, there is interest on the part of those concerned in the rates charged for such transportation and particularly in the trend of rates.

The writer, during various periods of the past decade, has given considerable study to various aspects of motor transportation. One phase of his study has been the rates charged for trucking the livestock. Since the competition between railroads and motor trucks has been intense during this period, it is interesting to note what the trend has been for motor rates for moving livestock.

Data were obtained from Ohio's three principal livestock markets—Cleveland, Cincinnati, and Columbus—from 1929 through 1938. The data for the distances over 50 miles were not as complete for the earlier as for the later years. However, an examination of table 1 shows little difference between the rates for distances under 50 miles and those for 50 to 100 miles. The significant point, however, is that the rates in 1929 and 1930 were from 60 to 70 per cent higher than the rates during the past 3 or 4 years, whereas railroad transportation rates remained the same for all practical purposes during this period. Motor rates dropped rapidly during the depression. They did not make their low in 1932 when general business activity was at the bottom, but later. For the distances under 50 miles the low was made in 1934. Since that time rates have shown a tendency to rise slightly. For the distances over 50 miles the trend has remained downward although the years 1935, 1936, and 1937 were practically the same and a further drop occurred in 1938. From present indications it would seem that rates have about reached bottom.

**TABLE 1.—Index of trucking rates to Cleveland, Columbus, and Cincinnati combined for all species by a simple and weighted\* average for years 1929 to 1938**  
(1935 to 1937 equals 100)

Years	0 to 49.9 miles		50 to 99.9 miles	
	Simple average	Weighted average	Simple average	Weighted average
1929.....	164.3	172.1	175.3	175.8
1930.....	155.3	158.8	167.5	167.6
1931.....	137.7	144.5	143.6	146.8
1932.....	109.1	110.8	109.8	108.1
1933.....	102.2	101.2	106.2	106.6
1934.....	97.2	96.9	105.9	103.7
1935.....	98.9	98.9	100.2	99.1
1936.....	100.5	100.4	99.7	100.4
1937.....	100.4	100.6	100.2	100.2
1938.....	101.2	103.6	98.4	99.3

\*The weighted average was based upon the pounds by species marketed at the respective markets for the 3 years 1936 to 1938 inclusive.

Table 2 shows the same information as table 1, but detailed as to species. The rates for shorter distances as compared with the longer distances show much the same trend as where all species are combined. Calves are the exception. The rates for calves have declined less for the shorter distances. Lambs follow. Hog rates have declined the most.

**TABLE 2.—Index of trucking rates, by species, to Cleveland, Columbus, and Cincinnati combined by a simple average, for years 1929 to 1938**  
(1935 to 1937 equals 100)

Year	Cattle		Calves		Hogs		Sheep	
	0-49.9 miles	50-99.9 miles*	0-49.9 miles	50-99.9 miles*	0-49.9 miles	50-99.9 miles*	0-49.9 miles	50-99.9 miles*
1929.....	166.4*	176.4	148.4*	174.0	185.1*	175.6	157.4*	†
1930.....	153.4	166.4	141.2	167.0	167.6	169.1	159.2*	†
1931.....	145.8	146.6	129.6	139.0	149.4	148.4	125.9*	†
1932.....	114.9	110.4	111.8	114.4	106.6	104.7	103.0	†
1933.....	100.1	112.7	106.5	106.6	101.5	100.6	100.8	105.1
1934.....	94.8	106.2	99.0	107.8	98.8	99.5	97.1	110.0
1935.....	104.0	96.8	95.9	100.7	93.4	101.0	102.3	102.4
1936.....	98.6	101.2	98.3	102.1	102.1	100.7	103.2	94.8
1937.....	97.5	102.2	105.4	97.7	104.4	98.2	94.2	102.9
1938.....	103.5	102.2	101.9	106.9	106.0	97.6	93.4	86.9

\*Columbus not included—no data.

†Insufficient data.

There seems to be a tendency for rates to stabilize or rise slightly in recent years. An exception seems to be the rates for lambs. In conclusion, one can say that motor transportation rates for livestock in Ohio will probably stabilize around present levels. Of course, factors that would cause a raising or lowering of costs, such as a change in taxes or an abrupt change in the price level, wages, and the like, would no doubt have a decided influence on rates.

# INDEX NUMBERS OF PRODUCTION, PRICES, AND INCOME

J. I. FALCONER

From January to June the prices received by the Ohio farmer remained fairly stable, as did also the prices paid. In June, farm prices were 77 per cent of parity.

## Trend of Ohio prices and wages, 1910-1914=100

	Wholesale prices, all commodities U. S.	Weekly earnings N. Y. State factory workers	Prices paid by farmers	Farm products prices U. S.	Ohio farm wages	Ohio farm real estate	Ohio farm products prices	Ohio cash income from sales
1913.....	102	.....	101	101	104	100	105	101
1914.....	99	100	100	101	102	102	105	109
1915.....	102	101	105	98	103	107	106	112
1916.....	125	114	124	118	113	113	121	123
1917.....	172	129	149	175	140	119	182	201
1918.....	192	160	176	202	175	131	203	243
1919.....	202	185	202	213	204	135	218	270
1920.....	225	222	201	211	236	159	212	230
1921.....	142	203	152	125	164	134	132	134
1922.....	141	197	149	132	145	124	127	133
1923.....	147	214	152	142	166	122	134	147
1924.....	143	218	152	143	165	118	133	150
1925.....	151	223	157	156	165	110	159	180
1926.....	146	229	155	145	170	105	155	183
1927.....	139	231	153	139	173	99	147	171
1928.....	141	232	155	149	169	96	154	163
1929.....	139	236	153	146	169	94	151	172
1930.....	126	226	145	126	154	90	128	142
1931.....	107	207	124	87	120	82	89	105
1932.....	95	178	107	65	92	70	63	77
1933.....	96	171	109	70	74	59	69	87
1934.....	110	182	123	90	77	63	85	102
1935.....	117	191	125	108	87	66	110	132
1936.....	118	199	124	114	100	71	118	152
1937.....	126	215	130	121	118	75	128	162
1938.....	115	207	122	95	117	74	103	138
1937								
January...	125	209	130	131	104	.....	128	147
February..	126	211	132	127	.....	.....	127	141
March.....	128	218	132	128	.....	75	129	167
April.....	128	219	134	130	118	.....	134	182
May.....	127	219	134	128	.....	.....	135	162
June.....	127	220	134	124	.....	.....	134	162
July.....	128	218	133	125	123	.....	138	174
August.....	128	220	132	123	.....	.....	135	167
September.	128	215	130	118	.....	.....	129	164
October....	125	214	128	112	127	.....	123	165
November..	122	205	127	107	.....	.....	116	161
December..	119	207	126	104	.....	.....	114	147
1938								
January...	118	201	126	102	115	.....	109	139
February..	116	204	126	97	.....	.....	105	125
March.....	116	205	125	96	.....	74	106	135
April.....	115	204	125	94	116	.....	104	132
May.....	114	201	125	92	.....	.....	104	139
June.....	114	202	124	92	.....	.....	106	136
July.....	115	205	123	95	119	.....	106	157
August.....	114	208	122	92	.....	.....	100	139
September.	114	214	121	95	.....	.....	102	139
October....	113	212	121	95	119	.....	96	136
November..	113	207	121	94	.....	.....	98	142
December .	112	212	120	96	.....	.....	98	141
1939								
January...	112	211	120	94	115	.....	94	118
February..	112	213	120	92	.....	.....	94	117
March.....	112	218	120	91	.....	.....	92	121
April.....	111	211	120	89	116	.....	91	122
May.....	111	210	120	90	.....	.....	95	134
June.....	110	.....	121	89	.....	.....	93	129
July.....	.....	.....	.....	.....	118	.....	.....	.....

## NEW MONOGRAPH BULLETINS

**Bulletin 594. Cloth Houses. 1938. Alex Laurie and Conrad Link.** The authors tell the grower where and how to construct his cloth house and how to prepare the soil in it. They discuss the factors influencing growth under cloth and results obtained with a large number of flowers grown in cloth houses. The authors also give experimental results obtained with nursery stock.

**Bulletin 595. Potato Flea Beetles and Their Control. 1938. Harry L. Gui.** This bulletin summarizes the research activities of the Department of Entomology in the potato flea beetle project for the 5-year period from 1930 to 1934 inclusive. The control aspects of the problem have been given the greater emphasis; however, certain imperfectly understood biological phases have received some attention.

**Bulletin 596. Winter Injury of Fruit Trees in Ohio. 1938. Leon Havis and I. P. Lewis.** This bulletin contains a detailed report of the injury to Ohio fruit trees during the winter of 1935-36, as well as brief accounts of other severe winters in which damage is known to have occurred. The authors base the material of the bulletin on information secured from the 18 most severe winters in Ohio during the last 167 years, on a survey of the injury during the winter of 1935-36, and on literature pertaining directly to injury like that observed in Ohio.

**Bulletin 597. Local Government in Two Rural Ohio Counties. 1938. H. R. Moore.** The primary purpose of this bulletin is to present facts on public finance which will aid rural people to understand the developments which are affecting local government at present and possibly shaping its future.

**Bulletin 598. Forest Fires in Ohio 1923 to 1935. 1938. Bernard E. Leete.** Ever since the control of forest fires became a function of the State Division of Forestry, written reports, on standardized forms, setting forth in detail the more important facts concerning each individual fire, have been kept on file in the southern Ohio office of the Division. From January 1, 1923, to December 31, 1935, 3,034 of these reports accumulated. It has been standard practice since 1927 for the division warden to make a personal investigation on the ground of every fire as soon as possible after its occurrence. The local warden's report is then checked for errors and omissions, and an investigation is made into the cause of the fire. It is the purpose of this publication to subject this information to careful study and analysis.

**Bulletin 599. Spraying Program and Pest Control for Fruit Crops. 1939. (Also published as Bulletin 128 by the Agricultural Extension Service, The Ohio State University).** This bulletin discusses the standard spray materials now offered for sale and suggests proper combinations that will control both insects and diseases without causing spray injury to the fruit and foliage. It has been prepared after considerable discussion of the effectiveness and safety of the materials and combinations suggested, and these have been thoroughly tested and approved.

**Publications of the Ohio Agricultural Experiment Station may be obtained by sending a request to the Mailing Room, Ohio Agricultural Experiment Station, Wooster, Ohio.**



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## Ohio Agricultural Experiment Station

WOOSTER, OHIO, U. S. A.



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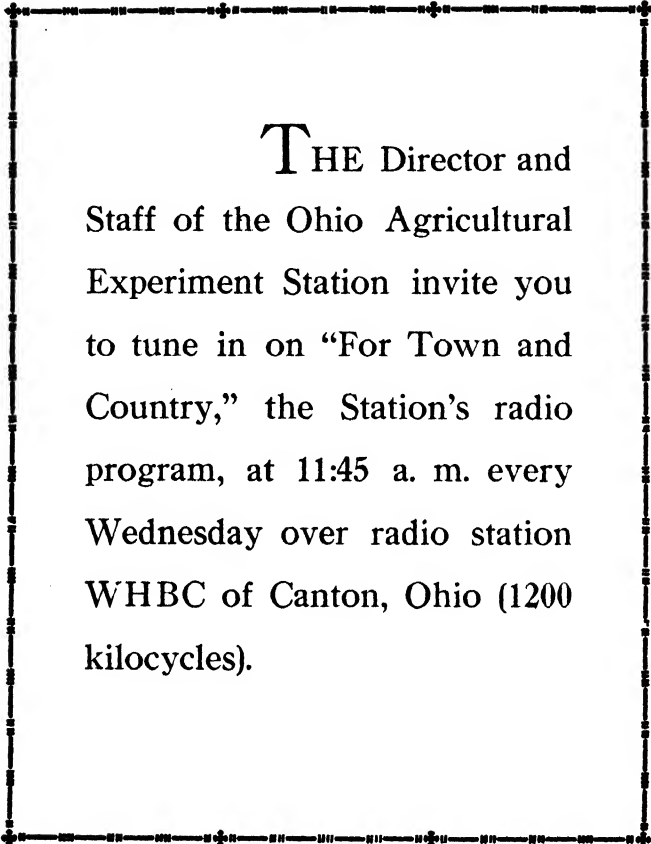
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# RATIONS AND METHODS OF FEEDING LAYERS

D. C. KENNARD AND V. D. CHAMBERLIN

What is the best ration and method of feeding layers? This has always been and continues to be an important question among poultrymen. The purpose of this discussion is to consider some of the representative rations and methods of feeding layers and to present the results of a recently completed project by the Station to secure experimental evidence upon a few of the newer angles of feeding layers.

## THE RATIONS AND METHODS OF FEEDING

Three feed mixtures (table 1) and four methods of feeding were employed with six groups of 45 White Leghorn pullets.

TABLE 1.—Ingredients of feed mixtures and prices

Ingredients	Price per cwt.	Group numbers and feed mixtures*		
		1, 2, 5	3, 4	6
		<i>Pct.</i>	<i>Pct.</i>	<i>Pct.</i>
Yellow corn, whole .....	\$1.20			None
Yellow corn, coarsely ground .....	1.30	20		20
Oats, whole .....	1.40			20
Oats, ground medium fine .....	1.50	12		10
Wheat middlings .....	1.50	20	12	20
Wheat bran, coarse .....	1.40	10	12	10
Meat scraps, 50-55 per cent protein .....	3.00	15	30	7
Soybean oil meal .....	1.60	5	10	2.5
Dried skimmilk .....	5.00	10	20	5.0
Alfalfa leaf meal† .....	2.50	7	12	5.0
Bone meal, special steamed .....	2.50		2	
Salt .....	1.50	1	2	.5
Cod-liver oil‡ .....	15.00	1.5	3	.5
Percentage protein§ .....		22.0	32.0	17.3
Cost per hundred pounds .....		\$2.30	\$3.25	\$1.80

\*Percentage of ingredients exclusive of cod-liver oil.

†Dehydrated.

‡200 AOAC chick units of vitamin D per gram.

§Calculated.

Groups 1, 2, and 5 received the 22 per cent protein laying mash, 3 and 4 received the 32 per cent protein supplement mash, and 6 received the whole oats-mash mixture. The methods of feeding the six groups were as follows:

1. Free choice of whole corn, whole oats, and 22 per cent protein laying mash
2. Same as 1 with free choice of whole grain restricted to 2 hours (2 to 4 p. m.) daily
3. Free choice of whole corn, whole oats, and 32 per cent protein mash supplement
4. Same as 3 with free choice of whole grain restricted to 2 hours (2 to 4 p. m.) daily
5. Same as 2 but supplemented with dried skimmilk
6. Whole oats-mash mixture only before the birds at all times

The whole corn and oats were fed groups 1, 2, 3, 4, and 5 daily in the evening in the amount that would be about consumed before the next feeding period. The mash was fed these groups daily in the morning in the amount that would be about consumed before the next feeding period. The whole oats-mash mixture was fed group 6 morning and evening in the amount that would be about consumed between feeding periods. The dried skimmilk supplement fed group 5 at noon was prepared by mixing 1 part of dried skimmilk with 3 parts of water by weight. The creamy paste was poured into the mash feeder on top of the dry mash in the amount that would be consumed within about 30 minutes.

The feed price used in these and later calculations was a price that was considered a representative average in the vicinity of Wooster, Ohio, from November 1938 to August 1939 when the feed was purchased by the ton.

In table 1 it will be observed that only group 6 was given a definite ration. All the other groups were given a definite mash mixture and were allowed to balance their rations as they chose with whole corn, whole oats, and the mash by the free-choice method of feeding. Now the question arises—can a hen be depended upon to balance her ration properly or should the ration be balanced for her? The answer to this question will be found in table 2.

TABLE 2.—Percentage composition of total feed consumed

November 23, 1938, to September 13, 1939, 42 weeks

Ingredients	Group numbers, rations, and percentage of ingredients*					
	1†	2†	3†	4†	5‡	6§
	Pct.	Pct.	Pct.	Pct.	Pct.	Pct.
Whole grain						
Corn.....	46.6	41.3	54.7	48.9	35.9	.....
Oats.....	13.4	13.8	20.7	21.8	14.7	20.0
Mash						
Corn, ground.....	8.0	9.0	.....	.....	9.2	20.0
Oats, ground.....	4.8	5.4	.....	.....	5.6	10.0
Wheat middlings.....	8.0	9.0	2.9	3.5	9.2	20.0
Wheat bran.....	4.0	4.5	2.9	3.5	4.6	10.0
Meat scraps, 50 per cent protein.....	6.0	6.7	7.4	8.8	6.9	7.0
Dried skimmilk.....	4.0	4.5	4.9	5.9	7.9****	5.0
Soybean oil meal.....	2.0	2.2	2.5	2.9	2.3	2.5
Alfalfa leaf meal  .....	2.8	3.2	3.0	3.5	3.2	5.0
Bone meal (special).....	.....	.....	.5	.6	.....	.....
Salt.....	.4	.4	.5	.6	.5	.5
Cod-liver oil**.....	.6	.7	.7	.9	.7	.5
Percentage protein***.....	14.7	15.3	15.2	16.3	16.4	17.3
Percentage whole grain.....	60.0	55.1	75.4	70.7	50.6	20.0
Percentage corn, whole and ground.....	54.6	50.3	54.7	48.9	45.1	20.0
Percentage oats, whole and ground.....	18.2	19.2	20.7	21.8	20.3	30.0
Percentage grain, whole and ground.....	72.8	69.5	75.4	70.7	65.4	50.0
Percentage mash.....	40.0	44.9	24.6	29.3	49.4	80.0
Percentage oyster shells.....	4.0	4.0	4.2	3.5	4.1	4.8
Percentage granite grit.....	.7	1.2	.7	2.4	1.1	1.2

\*Not including cod-liver oil.

†Free choice of whole corn, whole oats, and mash at all times.

‡Free choice of whole corn and whole oats restricted to 2 hours daily, mash available at all times.

§Whole oats-mash mixture before birds at all times.

||Dehydrated.

\*\*Two hundred AOAC chick units of vitamin D per gram.

\*\*\*Of total feed.

\*\*\*\*4.7 in mash plus 3.2 as supplement.

Here we have the actual percentage composition of the rations on the basis of total feed intake consumed by the layers in groups 1, 2, 3, 4, and 5 by the free-choice and restricted free-choice method of feeding in direct comparison to that of group 6, whose ration was prepared in accordance with some of our ideas. We believed that oats, wheat middlings, and wheat bran might be used in liberal amounts to advantage in rations for layers, and group 6 was fed in accordance with this idea. By the free-choice method of feeding whole corn, whole oats, and the mash mixtures used, groups 1, 2, 3, 4, and 5 consumed a much larger proportion of whole corn with a correspondingly smaller intake of middlings and bran than group 6.

Obviously the hen balances her ration largely on the basis of protein. Consider that groups 1 and 3, having free choice of corn, oats, and mash, varied only one-half of 1 per cent in their percentage of protein intake although group 1 received a 22 per cent protein laying mash and group 3 received a 32 per cent protein supplement mash. What better proof need these layers have given of their ability to balance their rations? What is more, if the mash is well balanced with the essential nutrients, the proper protein intake automatically ensures adequate intakes of the other essentials, such as the mineral- and vitamin-bearing materials, as evidenced in the percentage of mash ingredients given in table 2.

A frequent contention about free-choice feeding of whole corn, whole oats, and a mash is that the layers may eat too much grain and not enough mash. There was no evidence to substantiate this contention with the mash mixtures used in this experiment. Insofar as groups 2, 3, 4, and 5 were concerned, the intake of cod-liver oil was at a higher level than necessary. There may be a liability of insufficient intake of the mash for best results with a 16 to 18 per cent protein laying mash or with the free-choice feeding of whole wheat, corn, and oats. For these reasons it may be preferable to use a mash containing not less than 20 per cent protein and to restrict the free choice of whole grain to corn and oats.

If it is desired to feed whole wheat, which may be regarded as too palatable for free-choice feeding, it is generally advisable to restrict the amount to 2 to 4 pounds (1 to 2 quarts) per 100 layers daily. The whole wheat may be fed in this amount in the mash feeders on top of the mash or it may be fed in clean straw litter.

The restriction of the whole corn and oats to 2 hours daily did increase mash consumption and reduce the intake of corn by groups 2 and 4 (in comparison to groups 1 and 3, not restricted) but it did not likewise affect the intake of whole oats. The restriction increased the cost of feeding and did not increase egg production.

It is interesting to note the reduced proportion of whole grain (corn) to mash taken by group 5, which received the dried skim milk supplement, in comparison to group 2, which had the same ration and method of feeding without the supplement. Might it not have been expected that the additional dried skim milk (3.2 per cent) would substitute the mash rather than the whole grain?

The consumption of oyster shells was much the same by all groups. There is no question as to why a layer consumes oyster shells. But why does a hen eat hard grit? Presumably she does it to grind whole grain or coarse feed. Or is there another reason? In table 2 it will be observed that the grit intake of groups 1 and 3 was less than that of the corresponding groups 2 and 4,

which had access to whole grain only 2 hours daily. May whole grain or coarse feed substitute in a measure for grit? May grit be more necessary as a vehicle for mash than for whole grain? May grit be used as a physical factor (a vehicle) in connection with the digestive processes rather than for grinding purposes? With these questions in mind, it is interesting to note that group 2, having access to whole grain restricted to 2 hours daily, consumed about twice as much grit as group 1, having access to whole grain at all times. More to the point was group 4, having access to whole grain restricted to 2 hours daily with only a highly concentrated (32 per cent protein) mash of finely ground material available at all times (aside from grit and oyster shell), which consumed three times more grit than group 3, which received the same mash with whole corn and oats available at all times.

Extensive tests by this Station have definitely indicated the inferiority of finely ground mash for layers in comparison with the same mash mixtures composed largely of coarse material. Where finely ground mash is employed, especially if a concentrate, with restriction of whole grain, as in the case of group 4, it may be advisable to give more attention to the question of hard grit. Possibly grit should be mixed with the mash at the rate of 1 to 2 per cent of the total feed intake. Certainly this is true for layers in batteries.

Which was the best ration and method of feeding? Table 3 indicates the answer to this question in so far as this project was concerned.

**TABLE 3.—Egg production, feed consumption, and costs**  
November 23, 1938, to September 13, 1939, 42 weeks

Group number	Egg production		Feed consumed		Cost of feed			Returns from eggs* over cost of feed per bird
	Per cent	Per bird	Per bird	Per dozen eggs	Per cwt.	Per bird	Per dozen eggs	
			<i>Lb.</i>	<i>Lb.</i>			<i>Cents</i>	
1.....	53.7	158	64.5	4.90	\$1.67	\$1.08	8.2	\$2.08
2.....	52.3	154	65.4	5.10	1.72	1.12	8.7	1.96
3.....	51.7	152	62.2	4.91	1.74	1.08	8.5	1.96
4.....	52.0	153	67.0	5.25	1.84	1.23	9.6	1.83
5.....	55.6	164	68.7	5.02	1.86	1.28	9.4	2.00
6.....	58.8	173	71.2	4.94	1.80	1.28	8.9	2.18

\*At 24 cents per dozen.

Egg production, feed consumption, and cost of feed were practically the same for groups 1, 2, and 3, regardless of whether the layers received a 22 per cent laying mash or a 32 per cent protein supplement mash. The cost of feed and the cost of egg production were greater for group 4, with access to whole grain for only 2 hours daily, because of the decreased consumption of whole corn and the corresponding increased intake of the 32 per cent protein mash. The slightly lower cost of feed per hundredweight and the few more eggs laid by group 1 enabled this group to yield the slightly higher return from eggs over cost of feed. Aside from this, the results from groups 1, 2, and 3 were surprisingly similar.

Group 5 received the dried skim milk supplement in addition to the ration received by group 2. Presumably the milk supplement can be credited with yielding 10 more eggs per bird, and certainly it did increase the cost of feed so that the additional eggs no more than paid for the additional milk, without including the loss of time and the labor of feeding the supplement.

The whole oats-mash mixture (group 6) yielded the highest egg production, and, despite the high cost of feed, yielded the highest returns from sale of eggs over the cost of feed. The high cost of the whole oats-mash ration was largely due to the greater proportion of the higher priced oats, middlings, and bran in it than in the rations received by groups 1, 2, and 3, which contained more of the lower priced corn (table 2). The favorable results from this comparatively new type of ration are suggestive. Moreover, this ration has proved especially well adapted for feeding layers in batteries.

There was no significant difference between the rates of mortality in any of the groups. The body weights of the layers were similar for all groups except 4, whose weights were less, probably because of the high-protein mash and the restriction of the whole grain to 2 hours daily.

Obviously, this project has not definitely indicated which was the best ration or method of feeding. It is evident that there was a surprising similarity of results secured from each of the rations and methods of feeding, despite their differences. It would seem that any one of the six procedures, with the possible exception of number 4, might be employed with the expectation that similar results would be secured from White Leghorn pullets.

## RELIABILITY OF RETAIL PRICES AS GUIDES TO THE QUALITY OF POTATOES

CHAS. W. HAUCK

Wide variations exist in quality and prices of consumer goods available in the market. Very few of these goods are labeled, in terms readily understandable to the layman, to reveal their utility and serviceability to consumers. Truly expert buyers are exceptional, and even when the goods are unpackaged and displayed in such a manner as to permit ready examination, most consumers find intelligent purchasing difficult. When the merchandise is offered in rigid, opaque, sealed containers, selection is made with even less knowledge.

The consumer makes his choice from among competing products by placing reliance upon the claims of the producer or distributor, or upon the price, or upon the integrity and reputation of the vendor, or (in the case of branded merchandise) upon his own past experience with given brands. If the merchandise is offered in bulk without accompanying grade designation or other information except the price per unit, as is common practice with most fresh fruits and vegetables in retail stores, the purchaser is dependent largely upon what skill he may possess in evaluating the goods and comparing different lots. Lacking that skill, consumers are wont to fall back upon prices as buying guides.

How dependable are prices as buying guides? May one be assured of higher quality by paying higher retail prices? Do lower retail prices accurately reflect lower quality? Most fresh fruits and vegetables are classified carefully into distinct gradations of quality at points of origin. Wholesale and jobbing transactions are executed largely on the basis of these grades, at prices which tend to reflect differences in quality. Do prices to consumers also tend to reflect quality, and if not, is this fact of significance to producers, to distributors, and to consumers?

Some light on these questions, in so far as they relate to white potatoes, is shed by a study of price and quality relationships of a series of 100 samples of potatoes, each of 15 pounds, purchased in each of 100 representative retail grocery stores in Columbus, Ohio. The quality (or consumer acceptability or use value) of each of these 100 samples was determined and expressed numerically in the form of a comprehensive index, and this series of index numbers was then correlated statistically with the price series to determine what relationship existed between quality and price. Prices and quality indexes of these samples are given in table 1.

TABLE 1.—Quality and prices of 100 samples of white potatoes purchased in 100 retail stores in Columbus, Ohio

Sample number	Index of acceptability (quality)	Price paid (dollars)	Sample number	Index of acceptability (quality)	Price paid (dollars)	Sample number	Index of acceptability (quality)	Price paid (dollars)
8.....	97.3	0.45	60.....	87.6	0.50	23.....	78.0	0.40
26.....	97.3	.35	42.....	87.4	.37	56.....	77.7	.35
92.....	97.0	.40	96.....	87.3	.45	72.....	77.0	.37
63.....	96.7	.35	31.....	86.8	.35	27.....	76.6	.39
68.....	95.8	.45	15.....	86.7	.45	51.....	76.3	.59
43.....	95.5	.50	93.....	86.7	.43	90.....	76.3	.38
35.....	95.1	.39	59.....	86.6	.35	1.....	76.1	.37
30.....	94.7	.45	4.....	86.0	.45	65.....	75.9	.35
62.....	93.3	.45	34.....	85.8	.35	75.....	75.2	.50
67.....	92.5	.35	79.....	85.8	.33	70.....	74.6	.35
97.....	92.3	.45	33.....	85.4	.45	16.....	73.9	.35
21.....	92.2	.40	47.....	85.4	.50	48.....	73.7	.50
32.....	92.2	.45	11.....	85.2	.45	72.....	73.4	.45
38.....	92.0	.45	55.....	85.1	.38	88.....	73.4	.45
80.....	91.9	.40	74.....	84.9	.45	13.....	72.3	.50
98.....	91.9	.50	41.....	84.5	.35	64.....	72.3	.35
46.....	91.7	.45	94.....	84.4	.38	22.....	70.6	.40
28.....	91.6	.43	82.....	83.9	.35	61.....	66.7	.39
25.....	91.5	.39	85.....	83.9	.45	49.....	66.6	.38
58.....	91.2	.45	9.....	83.2	.40	52.....	66.2	.39
66.....	91.2	.45	81.....	83.2	.37	53.....	65.7	.35
18.....	91.1	.40	10.....	82.9	.45	78.....	64.5	.38
77.....	90.8	.35	57.....	82.6	.35	50.....	63.8	.35
83.....	90.6	.40	89.....	82.6	.42	29.....	61.5	.35
99.....	90.2	.40	5.....	82.0	.40	91.....	58.3	.46
36.....	90.1	.37	17.....	82.0	.39	86.....	54.6	.45
73.....	89.9	.35	54.....	81.8	.45	6.....	41.8	.70
19.....	89.7	.35	20.....	81.3	.45	100.....	41.4	.40
45.....	89.4	.35	37.....	81.0	.35	24.....	38.0	.60
2.....	89.2	.37	14.....	80.3	.35	95.....	26.9	.45
44.....	88.8	.37	84.....	80.1	.37	Average	81.4	.412
71.....	88.7	.45	7.....	79.1	.40			
39.....	88.0	.50	76.....	78.4	.37			
40.....	87.9	.35	12.....	78.1	.50			
3.....	87.8	.37	69.....	78.1	.45			

The most striking fact issuing from this study is that these retail prices were unreliable guides to the quality or use value of these purchases. The quality-price relationship, expressed statistically by a coefficient of correlation of  $-0.261$ , was so slight as to be almost wholly without significance. As a matter of fact, this coefficient, being a minus value, actually indicates a tendency toward inverse relationship; i. e., the higher the price the lower the quality.

It is clear that buyers would have had no justification whatever for placing any reliance on the price as being indicative of the quality or use value of these potatoes. Prices alone were completely useless as buying guides. Consumers conscious of price only could have purchased potatoes more intelligently and more economically by relying upon (a) familiarity with quality factors and specifications, (b) knowledge of grades available in various stores, and (c) knowledge of prices at which these various grades were being offered. In short, the likelihood of obtaining the best possible value would have been materially increased by learning what to look for and by searching for it alertly.

Education of consumers to be more grade conscious and more price skeptical is indicated. Doubtless this education would be promoted in a large degree if potatoes either in bulk or in packages were to carry conspicuously the appropriate grade designation in retail stores until purchased by the consumer.

A closer relationship between quality and price would seem to be advantageous to producers as well as to consumers. Potato growers have protested that wholesale buyers often will not pay a premium for high quality, uniformly graded potatoes sufficient to justify the expense required to sort the crop carefully. Wholesalers and jobbers in turn claim to be unable to offer much, if any, more for top quality because their customers, the retailers, will not pay enough more for it to yield a profit. Many retailers object to paying higher prices for U. S. No. 1 potatoes or better so long as potatoes of lower quality are available in the market at lower prices, on the grounds that few consumers recognize differences in quality and that, therefore, the retailer's margin is greater on low-priced than on high-priced potatoes.

Were consumers generally to come to recognize the characteristics of potato quality, it is likely that price differentials throughout the market channel would in turn tend to correspond to grade differentials. Thus would buying and selling tend to become more stable and more equitable. Thus would standardization be greatly encouraged. Thus would the consumer improve his chances of getting his money's worth. Thus would producers tend to secure proportionate premiums for proportionately better quality.

To state the case for more informative labeling is not to enter a plea for more grading. It is altogether possible that we have too much grading as it is. Grading can be overdone and become a costly luxury to society, if not to the individual. Unless it can be shown that a particular method of classification of goods reflects actual rather than fictitious needs and purchasing ability of buyers, such grading cannot be defended as an economic function.

Doubtless much standardization of farm products has been adopted by producers and the trades primarily as a device to yield higher returns and permit exaction of higher prices than would otherwise be possible, without sufficient consideration to the preferences of consumers, or to the ability of consumers to judge relative values, or to gradations of consumer purchasing power. Growers and shippers in distant producing areas generally have been interested in the establishment of a type of standardization which would facilitate large-scale merchandising methods. They wanted standards which could be made a basis for quotations and dealing in the produce nearly 2 weeks before it could be delivered in the market. Consequently, the federal grades for fresh fruits and vegetables were based in part on the grading and packing methods followed by these large-scale operators, and in part on investigation of accepted practices in the produce trade.

A new concept of grades is taking root, however. Emphasis appears to be shifting to a modification of grading standards that eventually may provide quality classifications in which a grower may divide his total crop for marketing in such a way as to obtain the maximum net returns for his time and money invested for the year, and which will enable consumers to purchase the crop in such a manner that they receive maximum value for each dollar spent.

Although studies of consumers' needs and buying practices are being made with greater frequency and greater skill, and under a wider variety of conditions, relatively little is yet known about the sizes and qualities of produce consumers in various income groups prefer and are able and willing to pay for. What is known has not yet exerted any measurable influence on the grades for those products. Relatively little is yet known about the comparative acceptability to consumers of Grade 1 and Grade 3, for example—acceptability based not upon dietetic and caloric considerations alone, but also upon the purposes for which the goods are to be used.

It is conceivable that sufficient study of factors of this sort might point the way to marked changes in grading standards now in use. Possibly less sorting into separate classifications than is now thought necessary would be indicated, especially for merchandise not requiring long hauls or long storage periods. If so, considerable economies would be possible. In any event, labeling to permit ready identification of grades by consumers promises some substantial benefits.

## HYBRID AND OPEN-POLLINATED CORNS FOR PIGS

W. L. ROBISON<sup>1</sup>

During the winter of 1937-1938 comparisons of hybrid and open-pollinated corns for pigs were made at Wooster and at the Madison and Miami County Experiment Farms. The hybrid corn and the open-pollinated corn for each comparison were grown on the same farm and under similar conditions. The corn was shelled, ground, and mixed with the other feeds in definite proportions so that the ratio of corn to supplement was necessarily the same for the two groups in each of the three comparisons. The percentage of supplement in the mixture was reduced when the pigs averaged approximately 120 pounds in weight. The mixtures of corn and supplement were self-fed. Table 1 gives the results obtained.

The three hybrid corns were lighter in color, higher in moisture, and a trifle lower in protein than the open-pollinated corns with which they were compared. When examined over a glass-topped box containing an electric light, some kernels, as indicated by a more extensive opaque area about the germ, contained less horny and more white starch than others. The percentage of kernels in which the opaque area extended their full length is shown in table 1 under the designation of starchy kernels.

<sup>1</sup>Mr. M. A. Bachtell, the staff member in charge, cooperated in the experiments at the County Experiment Farms. Those at the Miami, Madison, and Paulding County Farms were carried out by P. A. Jones, H. W. Rogers, and R. Beatty, the respective superintendents of the three farms.

Three rather poorly doing pigs in lot 1 weighing 150 and three in lot 2 weighing 152 pounds were removed from the Madison County experiment at the close of the ninth week. Five of these were from some pigs that had been purchased for the test. The average gains of the pigs remaining in lot 1, fed open-pollinated corn, and lot 2, fed hybrid corn, at the close of the test were 1.29 and 1.31 pounds daily a head, respectively. Another pig in lot 2, which received the open-pollinated corn, did rather poorly, particularly during the last few weeks of the test, but was not removed. It gained 79 pounds in weight as compared with an average of 142.6 pounds for its pen mates. Excluding it, the pigs remaining in lot 1 at the close of the test had made an average gain of 1.36 pounds daily a head. The slowest gaining pig left in lot 2 gained 106

TABLE 1.—Open-pollinated and hybrid corns for pigs  
First year's experiments

	Madison Co. Exp. Farm Started Nov. 20, 1937		Miami Co. Exp. Farm Started Nov. 27, 1937		Ohio Exp. Station Started Nov. 17, 1937	
	1 Open-pol- linated corn Clarage	2 Hybrid corn U. S. 52	1 Open-pol- linated corn Wood- burn	2 Hybrid corn Is. 939	1 Open-pol- linated corn Clarage	2 Hybrid corn W 17
Tankage, soybean oil meal, ground alfalfa, and minerals*						
Shelling percentage.....	80.64	80.57	85.0	83.3	83.9	84.0
Moisture, pct.....	18.8	19.8	21.8	22.6	16.5	17.4
Protein, pct.....	9.0	7.5	9.3	8.9	8.9	8.2
Fat, pct.....	3.9	3.9	4.6	4.1	4.4	4.8
Starchy kernels, pct.....	20.0	30.0	7.0	27.0	9.0	33.0
Number of pigs.....	12	12	12	12	14	14
Initial weight per pig, lb..	50.9	50.7	60.1	60.3	50.9	51.0
Final weight per pig, lb..	190.8	193.3	204.0	197.1	213.2	212.5
Average daily gain, lb..	1.11	1.13	1.47	1.40	1.29	1.15
Days to gain 160 lb.....	124	122	109	115	125	139
Daily feed per pig, lb.:						
Ground corn, 15.5 per cent moisture.....	3.43	3.30	4.83	4.78	4.11	3.82
Liver meal.....	.02	.02	.01	.01	.02	.02
Tankage.....	.30	.29	.43	.43	.34	.32
Soybean oil meal.....	.32	.31	.44	.45	.36	.34
Ground alfalfa.....	.16	.17	.26	.26	.21	.19
Minerals.....	.07	.06	.10	.10	.08	.07
Cod-liver oil.....			.01	.01		
Total.....	4.30	4.15	6.08	6.04	5.12	4.76
Feed per 100 lb. of gain, lb.:						
Ground corn, 15.5 per cent moisture.....	307.93	292.05	328.81	342.62	319.61	330.53
Liver meal.....	1.43	1.40	.70	.78	1.92	1.80
Tankage.....	26.95	25.66	29.60	31.21	26.37	27.42
Soybean oil meal.....	28.38	27.06	30.31	32.00	28.29	29.22
Ground alfalfa.....	15.97	15.32	17.60	18.54	16.08	16.79
Minerals.....	5.99	5.75	6.60	6.95	6.03	6.30
Cod-liver oil.....			.43	.42		
Total.....	386.65	367.24	414.05	432.52	398.30	412.06
Cost of feed per 100 lb. of gain.....	\$4.44	\$4.22	\$4.76	\$4.98	\$4.56	\$4.71
Value of hybrid corn with open-pollinated corn as 100 per cent, pct.....		107.7		93.4		95.3

Shelled corn 49 cents, oats 28 cents a bushel; tankage \$2.50, "liver meal" \$6.00; soybean oil meal \$1.50, ground alfalfa 80 cents, minerals \$2.00, grinding corn 10 cents, grinding oats 15 cents a 100 pounds; cod-liver oil 10 cents a pound.

\*For a part of the time before the pigs averaged 120 pounds in weight "liver meal" made largely from liver but containing other tissue, was used in place of some of the tankage. While fed, the "liver meal" made up 2 per cent of the total feed.

Since some of the pigs showed a tendency toward crampiness, 0.4 per cent of cod-liver oil was included in the ration during the last 2 weeks of the Miami County experiment.

pounds in weight as compared with an average of 141.7 pounds for its pen mates. Exclusive of it, those remaining in lot 2 at the close had made an average gain of 1.35 pounds daily a head.

In the experiment at Wooster, a 66-pound pig was taken out of lot 1 at the close of the second week. Lot 1 was fed the open-pollinated corn.

In each of the three experiments the pigs fed the open-pollinated corn took slightly more feed daily a head than those fed the hybrid corn. In the Wooster and the Miami County Farm experiments they also made a little faster gains and somewhat greater gains per unit of feed consumed. The pigs fed the hybrid corns required an average of 8 days' more time than those fed the open-pollinated corns to fit them for market. Only the amounts of the various feeds required per 100 pounds of gain produced were considered in calculating the relative values obtained for the hybrid and the open-pollinated corns. The feed prices on which the calculations are based are given in the footnotes to table 1.

Four comparisons of hybrid and open-pollinated corns for pigs were made during the winter of 1938-1939. As in the preceding year, the hybrid corn and the open-pollinated corn for each comparison were grown on the same farm. The four pairs came from different localities. Both years the hybrid corns used were of varieties that were listed by G. H. Stringfield, who has charge of the corn breeding investigations at the Experiment Station, as suitable for such comparisons.

In the Madison County Farm experiment the corns were shelled and self-fed. Each group of pigs was given an equal amount of supplement daily a head. Until they averaged approximately 150 pounds in weight the pigs were given as much ground oats as supplement. In the Paulding County Farm experiment the corn was shelled, and it and the supplement were self-fed separately. The results of the two trials are given in table 2.

The pigs fed the hybrid corns in the two experiments took more corn daily a head but gained no faster and made a little less gain per unit of feed consumed than those fed the open-pollinated corns. Both groups of pigs in the Madison County Farm experiment made exceptionally rapid gains and required unusually small amounts of feed for each 100 pounds of gain produced.

In the experiments at Wooster and at the Miami County Farm the corns were shelled and ground and mixed with the supplement in definite proportions. The mixtures were self-fed.

Three comparisons of the open-pollinated and the hybrid corn were included in the experiment at Wooster. In one comparison seven purebred pigs, in another seven first-cross pigs, and in the third six three-breed backcross pigs to the lot were used.

The open-pollinated corn was high in moisture. Unfortunately, some of the ears molded in storage. The moldy condition doubtless affected the palatability and feeding value of the corn, but to what extent is not known.

Although less feed daily was taken in one of the comparisons, the three groups fed the hybrid corn outgained the similar groups fed the open-pollinated corn. In two of the three comparisons the hybrid corn produced greater gains per unit of feed and showed a higher value than the open-pollinated corn. Inasmuch as the extent of the mold probably differed in different batches of the open-pollinated corn, some variation in the results was not surprising. The combined data for the Wooster experiment are given in table 3.

**TABLE 2.—Open-pollinated and hybrid corns for pigs**  
 Second year's experiments, in which shelled corn was fed

	Madison Co. Exp. Farm, Dec. 8, 1938, to Mar. 9, 1939		Paulding Co. Exp. Farm, Dec. 10, 1938, to Mar. 18, 1939	
	1 Open- pollinated corn Clarage	2 Hybrid corn K 23	3 Open- pollinated corn Clarage	4 Hybrid corn W 17
	Ground oats, tankage, soybean oil meal, ground alfalfa, minerals*		Tankage, soybean oil meal, ground alfalfa, minerals*	
Shelling percentage .....	81.1	80.3	82.73	84.19
Moisture in corn as fed, pct. ....	17.7	17.1	16.60	18.40
Protein, pct. ....	8.65	9.20	8.07	8.85
Fat, pct. ....	3.54	3.98	3.92	2.98
Starchy kernels, pct. ....	10	15	21	18
Number of pigs .....	11	11	10	10
Initial weight per pig, lb. ....	51.8	50.1	47.8	47.8
Final weight per pig, lb. ....	211.3	209.4	199.7	203.3
Average daily gain, lb. ....	1.75	1.75	1.55	1.59
Days to gain 160 lb. ....	92	92	104	101
Daily feed per pig, lb.:				
Shelled corn, 15.5 per cent moisture .....	4.59	4.71	5.21	5.48
Ground oats .....	.44	.44		
Liver meal .....	.02	.02	.04	.04
Tankage .....	.23	.23	.39	.41
Soybean oil meal .....	.25	.25	.43	.44
Ground alfalfa .....	.14	.14	.24	.24
Minerals .....	.05	.05	.10	.10
Total .....	5.72	5.84	6.41	6.71
Feed per 100 lb. of gain, lb.:				
Shelled corn, 15.5 per cent moisture .....	262.09	269.16	336.00	345.44
Ground oats .....	25.14	25.17		
Liver meal .....	1.15	1.15	2.42	2.27
Tankage .....	13.01	13.02	25.55	25.52
Soybean oil meal .....	14.16	14.17	27.97	27.79
Ground alfalfa .....	7.87	7.88	15.54	15.44
Minerals .....	3.15	3.15	6.22	6.18
Total .....	326.57	338.70	413.71	422.64
Cost of feed per 100 lb. of gain .....	\$3.28	\$3.35	\$4.39	\$4.46
Value of hybrid corn with open-pollinated corn as 100 per cent, pct. ....		97.3		97.6

\* Some liver meal was included in the ration until the pigs averaged 120 pounds in weight.

Two comparisons of the hybrid and the open-pollinated corn were included in the experiment at the Miami County Farm. In one, 10 purebred and in the other, 10 three-breed backcross pigs to the lot were used. All the pigs remained healthy and gained well throughout the experiment. As determined from the feed required for each 100 pounds of gain produced, the hybrid corn was worth 90.4 per cent as much a pound as the open-pollinated corn in one comparison and 90.8 per cent as much in the other. The combined data are given in table 3.

A summary of the seven experiments in which hybrid and open-pollinated corns were compared is given in table 4.

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**TABLE 3.—Open-pollinated and hybrid corns for pigs**  
 Second year's experiments, winter 1938-1939, in which ground corn was fed

	Wooster		Miami Co. Exp. Farm	
	1 Open- pollinated corn Woodburn	2 Hybrid corn Iowa 939	1 Open- pollinated corn Golden Surprise	2 Hybrid corn U. S. 52
	Tankage, soybean oil meal, ground alfalfa, and minerals*			
Shelling percentage.....	85.98	84.30	82.79	86.16
Moisture in corn as fed, pct.....	20.80	18.35	20.70	17.05
Protein, pct.....	8.30	8.44	8.22	8.38
Fat, pct.....	3.25	2.05	3.30	3.65
Starchy kernels, pct.....	17	3	11	22
Number of pigs.....	20	20†	20	20
Initial weight per pig, lb.....	54.7	54.9	69.7	70.0
Final weight per pig, lb.....	199.3	202.4	205.8	204.3
Average daily gain, lb.....	1.35	1.39	1.77	1.74
Days to gain 160 lb.....	119	115	91	92
Daily feed per pig, lb.:				
Ground corn, 15.5 per cent moisture.....	4.24	4.34	5.48	5.88
Liver meal.....	.07	.07	.05	.05
Tankage.....	.29	.28	.42	.43
Soybean oil meal.....	.36	.35	.46	.48
Ground alfalfa.....	.22	.22	.28	.29
Minerals.....	.08	.08	.11	.11
Total.....	5.26	5.34	6.80	7.24
Feed per 100 lb. of gain, lb.:				
Ground corn, 15.5 per cent moisture.....	314.19	311.97	309.93	337.08
Liver meal.....	5.23	4.72	2.66	2.67
Tankage.....	21.13	20.40	23.67	24.67
Soybean oil meal.....	26.35	25.13	26.34	27.34
Ground alfalfa.....	16.43	15.80	16.21	16.85
Minerals.....	6.37	6.11	6.08	6.32
Total.....	389.70	384.13	384.89	414.93
Cost of feed per 100 lb. of gain.....			\$4.42	\$4.73
Value of hybrid corn with open-pollinated corn as 100 per cent, pct.....		102.9		90.4

\*Until the pigs averaged 120 pounds in weight, 2 per cent of "liver meal" was included in the ration in place of an equal amount of tankage.

†A 55-lb. pig was taken out at the close of the fourth week.

There was very little difference in the average amounts of feed consumed daily a head, or in the rapidity of the gains. An average of 2.4 per cent more feed for each 100 pounds of gain was required by the pigs fed the hybrid than by those fed the open-pollinated corns. With other feeds at the prices assigned and with only the amounts of the various feeds required for each 100 pounds of gain produced considered, the hybrid corns showed an average value 3 per cent less than that of the open-pollinated corns.

With the first year's Madison County Farm experiment, in which there was a poorly doing pig in the open-pollinated corn lot, and the second year's Wooster experiment, in which some mold was present in the open-pollinated corn, excluded, an average value 5.4 per cent less than that of the open-pollinated corns was obtained for the hybrid corns. In the five trials, the pigs fed the open-pollinated corns were ready for market 4 days earlier on the average than those fed the hybrid corns.

# HYBRID AND OPEN-POLLINATED CORNS FOR PIGS

**TABLE 4.—Summary of experiments comparing open-pollinated and hybrid corns for pigs**

	Open-pollinated corns	Hybrid corns
Number of comparisons .....	7	7
Pigs at start .....	99	99
Initial weight per pig, lb. ....	56.4	56.3
Pigs at close .....	95	95
Final weight per pig, lb. ....	203.8	203.7
Average daily gain, lb. ....	1.45	1.43
Days required to gain 160 lb. ....	111	113
Daily feed per pig, lb.:		
Corn, 15.5 per cent moisture .....	4.53	4.56
Ground oats .....	.04	.05
Liver meal .....	.04	.03
Tankage .....	.34	.34
Soybean oil meal .....	.38	.37
Ground alfalfa .....	.22	.22
Minerals .....	.08	.09
Cod-liver oil .....	.001	.001
Total .....	5.63	5.66
Feed per 100 lb. of gain, lb.:		
Corn, 15.5 per cent moisture .....	311.27*	319.92*
Ground oats .....	3.15	3.15
Liver meal .....	2.51	2.37
Tankage .....	23.45	23.76
Soybean oil meal .....	25.96	26.12
Ground alfalfa .....	15.27	15.41
Minerals .....	5.84	5.88
Cod-liver oil .....	.05	.05
Total .....	387.50	396.66
Cost of feed per 100 lb. of gain .....	\$5.31	\$5.42
Value of hybrid corn with open-pollinated corn as 100 per cent, pct. ....		97.0

\*Shelled corn was fed in two experiments. It amounted to 69.20 and 72.15 pounds of the open-pollinated and the hybrid corns, respectively.

To study their relative palatability, the eight corns used in the second year's experiments comparing hybrid and open-pollinated corns were shelled and self-fed separately to a group of six purebred and eight crossbred pigs. A supplement consisting of tankage, 34, soybean oil meal, 34, ground alfalfa, 24, minerals, 8, was kept before the pigs in a separate compartment of the feeders.

The pigs averaged 60 pounds in weight at the start and 280 pounds at the close. During the entire period they ate an average of 4.9 pounds of shelled corn and 0.8 pound of supplement daily a head, made a gain of 1.42 pounds daily a head, and consumed 344 pounds of corn and 51 pounds of supplement for each 100 pounds of gain produced.

From 60 to 215 pounds in weight they ate an average of 4.5 pounds of corn and 0.6 pound of supplement daily a head, made a gain of 1.38 pounds daily a head, and consumed 324 pounds of corn and 59 pounds of supplement for each 100 pounds of gain produced.

To prevent the pigs from eating more of one corn than of another merely because of its location in the feeders, each corn was moved to a new location or different compartment each week. After approximately 20 bushels of a particular corn had been consumed, that corn was withdrawn. This procedure was followed until only one variety of the eight remained.

When the pigs had consumed approximately 20 bushels of each, they were again given access to all eight of the corns, which were kept before them in separate compartments of the feeders for a period of 15 days.

TABLE 5.—Palatability of corns used in second year's experiments

	Corns						
	Pounds of each consumed; moisture reduced to 15.5 per cent						
	7	4	8	6	3	2	5
First period							
Jan. 4 to Jan. 11.....	99	8	43	8	15	26	13
Jan. 11 to Jan. 18.....	140	8	42	9	10	48	11
Jan. 18 to Jan. 25.....	176	5	28	13	0	8	6
Jan. 25 to Feb. 1.....	193	25	35	18	6	6	23
Feb. 1 to Feb. 8.....	226	15	9	23	8	53	13
Feb. 8 to Feb. 15.....	257	10	37	21	10	40	8
Feb. 15 to Feb. 22.....	76*	44	34	22	30	146	20
Feb. 22 to Mar. 1.....	136	79	36	38	99	15	44
Mar. 1 to Mar. 8.....	92	82	55	26	104	23	52
Mar. 8 to Mar. 15.....	118	63	54	69	87	14	15
Mar. 15 to Mar. 22.....	163	77	45	62	45	8	103
Mar. 22 to Mar. 29.....	174	138	109	40	9	8	42
Mar. 29 to Apr. 5.....	227	134	107	54	4	2	21
Apr. 5 to Apr. 12.....	261	144	128	65	6	3	3
Apr. 12 to Apr. 19.....		183	288	126	10	4	21
Apr. 19 to Apr. 26.....			187	359	7	7	9
Apr. 26 to May 3.....				251	289	5	61
May 3 to May 10.....					74	124	350
May 10 to May 17.....						573	46
May 17 to May 23 (6 days).....						240	211
Second period							
May 23 to May 31 (8 days).....	357	165	12	66	14	116	8
May 31 to June 6.....	304	189	80	3	13	42	3

\*In the last week each of corns 7, 4, 8, 6, 3, 2, 5, and 1 was fed during the first period, each, as named, was available for 2, 7, 6, 5, 5, 2, 4, and 6 days, respectively.

Identity of corns:

Open pollinated: 1. Woodburn 3. Clarage 5. Golden Surprise 7. Clarage  
Hybrid : 2. Iowa 939 4. K23. 6. U. S. 52 8. W17

Table 5 shows the weekly consumption of the different corns after they had been reduced to an equivalent moisture basis of 15.5 per cent. The corns are listed in the table according to their palatability during the first period rather than consecutively. With the exception of number 4, the figure for each corn the last week it was fed in the first period represented from 2 to 6 days rather than a full week's time.

The pigs soon learned to find the more palatable corns regardless of the location of the corns in the feeders.

Table 6 shows the quantities of each corn consumed daily a head during the first and second periods, together with the average percentage of moisture contained.





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